VOLUME LIX NUMBER 5 WHOLE 520

SCHOOL SCIENCE AND MATHEMATICS

MAY 1959

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Additional entry at Oak Park, Illinois, January 18, 1957. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE: Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Printed in the United States of America

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SCHOOL SCIENCE AND MATHEMATICS

VOL. LIX | MAY 1959 | WHOLE No. 520

Education: Gateway to Conservation

Joseph J. Shomon

Commission of Game and Inland Fisheries, Richmond, Virginia

Although conservation as a technology, as well as a way of living, has made notable advances in America, the vast majority of our people still lack an informed approach to natural resource values and problems. While the past half century has seen substantial progress in the scientific management of soil, water, forest, wildlife and fisheries—and to a degree in minerals—a much slower advance has been made through education in the acceptance of conservation as a philosophy of living.

Many examples can be shown to illustrate how slowly the conservation idea has been grasped by our people. Though soil conservation measures are now generally accepted as wise land use, the Mississippi still runs brown with mud, dumping countless tons of our best top soil in the Gulf each year. While we are cleaning up many of our rivers and streams, the once beautiful Potomac still carries raw sewage past the halls of Congress. Although scientific forest management is now being encouraged on most of our government and private forests, we are still removing in sawtimber three trees for each two that grow. Though we now have over 5,000 biologists engaged in wildlife management, research and education, we are losing valuable habitat for wild creatures every day. While we now are seeing the development of a fisheries profession, we seem powerless to reverse the downward population trend of the Pacific sardine and the Alaska salmon.

Paper presented at the 125th Meeting of the American Association for the Advancement of Science, Shoreham Hotel, Washington, D. C., December 26–30, 1958. Mr. Shomon is chief of the education division and editor of *Virginia Wildlife Magazine*, Virginia Commission of Game and Inland Fisheries, Richmond, Virginia.

Yet, in spite of seemingly good conservation progress, we are still losing priceless areas of wild lands—beaches, swamps and marshlands—areas of primeval America, which when once lost are gone forever.

Why must this be so? Why, the thoughtful observer asks, is America still losing ground in the face of the advances in science and education? Why is it that, in a nation blessed with a superabundance of natural wealth, we apparently haven't appreciated the importance of safeguarding what we have?

These are thought-provoking questions and they deserve some thoughtful answers. Surely many concerned with the problem of transferring conservation needs into conservation wants would agree that several good reasons can be found why conservation has not made greater headway in this country during the past half century.

To begin with, conservation is seldom a popular idea in a new country. For two and a half centuries ours was a primeval land with pioneer conditions. Under such circumstances and with a superabundance of natural wealth everywhere, it is small wonder people were reckless. Our forebears came to this country principally for the freedom and opportunity it afforded for all who would venture forth. And many came and many exploited, taking what seemed to be their right.

Secondly, our modern economic system encourages waste, which is contrary to the principle of conservation. While our free enterprise system is to be encouraged and admired and seems superior to any other in the world, even under this system good husbandry would dictate the control of needless waste.

Today, waste in government circles, particularly in military and in the marketing fields, is colossal. Likewise, shocking waste exists in industry, agriculture, and in the average home. With waste such a common sight everywhere, it is easy to see why Americans are not more conservation minded.

Thirdly, effective conservation has its source in a healthy conservation climate. Such a climate has never really existed in this country although the so-called conservation era began some fifty years ago. Several conditions have contributed to a cloudy conservation atmosphere: lack of consistent, long-range policies and such things as one state agency discounting the projects of another with respect to natural resources management at the federal and state levels; the tendency still to make natural resources affairs a political football; and weak and oftentimes conflicting programs of action by conservation agencies.

Finally, and perhaps most important of all is the inadequacy of the general educational effort to meet the mounting threat to our natural

resources base by the demands of an exploding population. This inadequacy, however, is only one aspect of the general inadequacy of our whole educational effort in this country. Here, for example, is how some of our prominent leaders view the situation:

"America's present predominantly super-kindergarten system of effortless education," said Dr. C. W. Shilling of the U. S. Atomic Energy Commission recently, "is endangering America's defense effort."

Speaking of America's struggle for national survival, he said solemnly:

> "Our only hope of protection lies in making maximum use of our intellectual resources. Although we cannot afford to fail in this area, it is in precisely this most crucial area where we find ourselves far behind."
>
> "Do you know that one-fourth of all American high schools offer no chemistry, one-fourth offer no physics, one-fourth offer no geometry and many offer no course in biology?"
>
> "And, worst of all, in many schools offering science and mathematics courses, the quality of instruction is unbelievably low. For example, last year in the relatively superior high schools of New York City, more than 10,000 students were in science classes taught by teachers who were not trained in any science."

Many other distinguished Americans feel much the same way about the present inadequacy of education.

Vice President Nixon said recently that education must develop the *whole man*. "A mental regime that lacks challenge leads to an undeveloped brain and a weak intellect."

J. Edgar Hoover, director of the Federal Bureau of Investigation, comments on the situation this way.

> "The time is opportune to reinform America of the inspiring story of our glorious democratic history of liberty, freedom, tolerance and justice. What is needed to revitalize the outlook of our youth is a total effort, beginning in elementary education and soundly bolstered in the home, to teach and preach the greatness of America, to make our history and our tradition live anew."

Dr. J. Allen Hyek of the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, says there must be a redirection of education.

Dr. Joel Hildebrand of the University of California says: "We are in peril from ignorance long tolerated at all levels from high school to high places in government."

And, there is the stern warning of a popular and noble ruler from across the seas. Queen Elizabeth appeared on television on December 25, 1957, to broadcast her annual Christmas message to the British Commonwealth—and used the occasion to say the following about the dangers in the nuclear age:

> "It's not the new inventions which are the difficulty. The trouble is caused by unthinking people who carelessly throw away ageless ideals as if they were old and outworn machinery."

"They would have religion thrown aside, morality in personal and public life made meaningless, honesty counted as foolishness and self-interest set up in place of self-restraint."

"At this critical moment in our history we will certainly lose the trust and respect of the world if we just abandon those fundamental principles which guided the men and women who built the greatness of this country and Commonwealth."

"Today we need a special kind of courage, not the kind needed in battle but a kind which makes us stand up for everything that we know is right, everything that is true and honest."

"We need the kind of courage that can withstand the subtle corruption of the cynics so that we can show the world that we're not afraid of the future."

"It has always been easy to hate and destroy. To build and cherish is much more difficult."

To repeat, then, our inadequacy in conservation education seems nothing more than a reflection of the general inadequacy of education that has prevailed in our country in recent years. If we can strengthen our whole general education effort, with appropriate emphasis on science, then conservation and such important areas of emphasis as *nature study* will be automatically strengthened.

Suggested Program of Action

If our conservation effort is inadequate to meet the challenge of the future, there must be something that can be done about it—and there is. A broad program of action in three areas is suggested: (a) the area of natural resources management; (b) the area of public conservation communications; and (c) the area of conservation education in the schools. The improvement and strengthening of each area is essential, and the effort should be simultaneous on all three fronts.

On the management front we need more and better leaders—administrators, scientists, managers. Also, more adequate financial support is needed for natural resources programs. A good administrator cannot do a good job with inadequate personnel and a constantly frustrating budget.

On the other hand, effective natural resources management demands more than just men and money. It demands spirit—a special kind of spirit that only dedicated and selfless men can give a worthy cause. It demands men with great powers of insight, and forethought, men with an enlarged sense of responsibility and dedication. It needs men of zeal who can fire the American subconsciousness into something noble—into an awareness and an understanding of man's place in a *natural* universe. Above all, it needs men of sensitivity—men like John Muir, Gifford Pinchot, Teddy Roosevelt, Aldo Leopold—men who love nature and who can pass on that feeling to others.

On the conservation communications front, great opportunities await development. At the present time the four mass communica-

tions media (press, radio, TV, and film) are not being used effectively —at least not on a broad enough scale in America to be effective. The press, in particular, as a great vehicle of conservation information needs better harnessing. Our state conservation magazines can be vastly improved. The use of radio and TV and film for the transmission of conservation knowledge has not been fully explored. Much the same can be said of all the other communications media.

Finally, an aggressive course of action is needed in several vital areas of conservation education itself: (1) primary and secondary school level; (2) college level; and (3) adult conservation education.

At the primary and secondary level, there is much to recommend a separate course of training in conservation. Concentrated courses both in the 6th grade and in the 9th or 10th grade might well be considered. Such an approach, of course, has never met with favor from most educators, the preference being for the more gradual integrated approach in all grades. The argument is advanced that present curricula are already too full to add another basic course. Be that as it may, the idea of a separate course of study is still worthy of serious thought.

Let's not kid ourselves. If a forceful impression is to be made on our growing citizenry of the importance of conservation, it seems doubtful this can be done through the present so-called method of concealed, painless integration.

Similarly, at the higher institutional level, greater concentration in the basic natural sciences is needed. Here again, at least one basic course in natural resources conservation should be required of every student—not just those majoring in forestry or wildlife or fisheries.

Conservation is not the concern of just a few specialists. If it concerns everyone, then *all* persons must be reached in conservation education training: the lawyer, scientist, engineer, the banker, preacher, house worker, laborer.

The argument again may be used that there is no room in the present curriculum for more course work. I say that for anything as vital as conservation, a *place* can and a place *must* be found. This idea that a place *can't* be found in our school system for additional courses vital to a well-rounded education is unfounded. We had better take sterner educational measures or our future is lost.

At the adult level, two areas of concentration need strengthening: the in-service training of teachers and mass adult conservation education. In the former area, much can be done through effective summer short courses or workshops in conservation. Here the states of Michigan, Tennessee, Ohio, New York, Missouri, and Virginia are doing outstanding work. More workshops for teachers are needed.

For coordination of the conservation education effort, one more

course of action is suggested. That is, that more use be made of qualified conservation coordinators or staff consultants. There is no reason why every state board of education should not have a supervisor of conservation education. Similarly, supervisors should be appointed to coordinate conservation education in all large natural resource agencies, state and federal, plus any large educational agencies and the military services. If such were the case, a more united conservation education front would soon be showing itself in America.

Now to summarize briefly: First, the conservation of natural resources remains one of the great problems of the twentieth century. In the experiences of the past half century—though remarkable progress has been made in many areas and is not to be discounted—the great bulk of the American people still lack an essential awareness of conservation needs and wants.

Many reasons can be cited for this lack of proper awareness: We are still a fairly new nation; our economic system, though commendable, encourages waste; management (natural resources) has had some unhealthy aspects; and we have fallen behind in our whole educational effort, conservation education included. There are indications that the rugged individualism and pioneer spirit that has characterized our ancestors has, in many respects, been dampened. A rekindling of the old spirit is in order. A sterner program of education and enlightenment, including a greater concentration in natural resource conservation, would be wise.

To achieve a greater degree of conservation in the next half century, an improved action program in three areas is suggested: (1) natural resources management; (2) conservation communications; and (3) conservation education on a tri-level basis. All three areas must be harnessed together. If we do so, our glorious natural heritage will be assured—and so will the strengthening of democracy in America.

OCEAN-ATMOSPHERE LINK FOUND FOR PACIFIC WATERS

The problems of finding sardines and other fish in the eastern North Pacific were linked to the general circulation pattern of the atmosphere by a Weather Bureau meteorologist.

Jerome Namias, head of the Bureau's extended forecast section in Suitland, Md., reported to the American Meteorological Society meeting that he had found a relationship between the long-period air circulation and surface temperatures of the ocean.

West Coast fishermen in recent years have been catching many kinds of southern fish much farther north than usual. Mr. Namias' new theory is expected to make it possible for scientists to predict where the warm, fish-containing waters will be by calculations based on how the atmosphere is behaving.

Today's Space Age Needs Chemistry's Cornucopia*

Marshall D. McCuen
Allison Division, General Motors Corp.

In the gray dawn of one morning during the week of May 19, 1958, an historic event took place over the South Atlantic Ocean. A strange looking object came floating down out of the sky on a parachute. Attached to it was a balloon on a cable. When the object hit the water, it sank to the end of the cable. With the balloon riding the water several things happened fast. A depth charge was set off, a light started flashing, a red dye was dissolved in the water and a radio started sending signals. Shortly thereafter the U. S. Navy's salvage ship *Escape* arrived and fished the object from the water. This object, or an identical one, appeared beside President Eisenhower on T.V. a few days later when he announced that the United States had solved the missile nose cone re-entry problem. This story is an appropriate one for opening my remarks this morning because the material used in the Jupiter nose cone was a product of a chemical laboratory—a reinforced polymer plastic. Yes, plastics had successfully solved a problem where metals had failed. Another major contribution to the budding Space Age had been made by Chemistry.

Creating the title for a speech is similar to bringing out a new car. It takes time, some cooperation and when it's finished you're proud of it. I was especially proud of the title I originated for this speech last July when the cover of the November issue of *Aircraft and Missiles Manufacturing* magazine came out with a picture of a cornucopia made from the Periodic Table. Flowing from it were various components of Space Age vehicles. Hereafter, when you look at a Periodic Table in a chemical laboratory I hope many of you will think of this comparison.

The magazines and newspapers today are filled with pictures and descriptions of present and future supersonic aircraft, missiles and space vehicles. You may have heard of the X-15 which is scheduled to be the first *manned* aircraft to leave the earth's atmosphere and return. It will fly three times faster than the speed of sound to an altitude of more than 20 miles. We are all familiar with the more or less regular missile launchings at Cape Canaveral—some completely successful—many others not so successful. When we consider these projects, we wonder what some of the problems are which face America's scientists and engineers in their efforts to build these vehicles. Some of the major problems can be listed as follows:

(1) To provide materials of maximum strength with minimum weight for building the vehicles.

* Paper given before the Chemistry Section of the Central Association of Science and Mathematics Teachers, Inc. at the Claypool Hotel. Indianapolis, Indiana on November 29, 1958.

(2) To make fuels which will give maximum propulsion force for minimum weight and volume to propel the vehicles for great distances.
(3) To locate or make materials which will withstand the enormously high temperatures generated in the engines and when the vehicles re-enter the atmosphere.

This is quite an order! The fuel problem has received much more publicity than the material problems but I assure you they are all equally important.

When I attempted to make a list of problem areas connected with the Space Age which also had a close tie-in with chemistry, I was able to make a list which would be impossible to cover in the time available this morning. Some of those areas I was forced to eliminate were—

Propellents—solid and liquid fuels (I will make only a single reference to this area). Much of the information in this area is secret.
Plating—both chemical and electro-chemical coating of one metal on another for protection.
Ceramics—Both individually and as a protective coating for a metal like molybdenum which oxidizes rapidly at higher temperatures.
Powder Metallurgy—A rapidly developing industry.
Solar Batteries—Of satellite fame.
Plasma Jet—No connection with or similarity to blood plasma. Actually a mixture of atoms and ions which result when molecules of a gas are subjected to ultra high temperatures.

All very interesting subjects, I know, but a choice had to be made. I have selected five areas to cover in detail. They involve chemistry to a major extent. They are barely mentioned in high school chemistry texts if at all. They are of primary importance to the Space Age. They should provide interesting illustrative material which can be used in high school chemistry instruction. These areas are:

Area No. 1—Control of Carbon Content in Steel Production.
Area No. 2—Reduction of Weight by Using Chemicals to Remove Material.
Area No. 3—Solving a Major Heat Problem with an Unlikely Material.
Area No. 4—Improving Metal Strength by Using an Exotic Family of Elements.
Area No. 5—The Exciting Future of a Little Known Glamour Element.

The problem of the control of carbon content in steel production may well not interest you at first thought. Let's see if I can change your mind. First, let's put together certain facts. Steel production is the backbone of American industry. Industrial volume is directly tied to the capacity of the steel industry. Thousands of different steels are made to fill thousands of different requirements. Each different steel has a different analysis in which the content of carbon, sulphur, manganese, chromium, nickel, titanium, molybdenum and other elements, in the iron, must be accurately controlled during the making of the heat. In all the descriptions of the steel making process I was able to find in chemistry text books and encyclopedias, not one

mention was made of controlling the mixture or of the method of analysis.

Consider an open hearth steel furnace. A hundred tons of a mixture of molten iron, steel scrap, iron ore and limestone have been brought to a white heat. The problem for the men in the mill is to determine the chemical make-up of the mixture so that alterations can be made until the chemistry meets the specifications. The longer it takes to make the analysis the less production can be obtained from the furnace.

A furnace averages about three heats in 24 hours. An average of four sample analyses must be made for each heat. A small molten sample is taken from the furnace and sent by pneumatic tube to the laboratory. This sample is divided into two parts—one to analyze for carbon and the other to analyze for other elements.

Carbon content is the most important requirement in steel chemistry. A nonmetallic, carbon makes possible the control over the steel's strength, hardness and toughness. Most of the other metals are added for their effect on the iron-carbon relationship and incidentally impart certain other properties.

First, let us consider the method of analysis for the other elements. This has moved completely away from chemical wet analysis. To quote *Business Week* magazine "In large laboratories test tubes are being pushed aside in favor of the emission spectrometer, the nuclear resonance analyzer, the differential fractometer, the infrared spectrograph, the vapor fractometer or the mass spectrometer" " . . . the spectrometer operator loads the machine with a bit of metal delivered still warm by pneumatic tube from the metal shop. The machine buzzes for 3 seconds and dials spin. He jots down the figures and hurries them back to the shop in a total of 3 minutes elapsed time and with an accuracy of 1 part in 10,000." Yes, the metals and other elements can be checked by automatic machines. But not carbon.

In the dark ages of steel making, the only method available for checking carbon content was spark testing. The sample was held against a grinding wheel and the character of the sparks resulting gave a fair indication of the carbon percentage. In the last fifty years a number of methods have been invented by chemists and metallurgists for determining carbon content. A book put out by the U. S. Steel Corporation lists 15 such methods. However, most of them are either not accurate enough or are much too time consuming to be used in a steel mill.

In the 30's and early 40's a procedure was in use called the gravemetric method of carbon analysis. The sample was first volatilized in a current of oxygen. This liberated all the carbon in the form of CO_2. The CO_2 was run through an absorption bulb containing glass wool,

soda-asbestos and a desiccant such as anhydrone. The bulb was weighed before and after and the CO_2 absorbed was determined. This was converted into percentage of carbon content in the sample. This procedure took 8 to 10 minutes per sample.

In the 1940's a new procedure was originated. Known as the gaseometric method, the CO_2 was generated by the same method as above. A quantity of gas containing the CO_2 was trapped in a standard volume. This mixture was then run through an absorption bulb containing potassium hydroxide with which the CO_2 reacts to form potassium carbonate and water. The change in volume is determined after the CO_2 has been removed and a direct percentage for the sample is determined. This procedure requires 2 to 3 minutes to run a sample. Think of it. Six to seven minutes *saved on each analysis* by the new method over the old one. Multiply this by 4 samples per heat, 3 heats per day, by the number of working days in a year, and by the number of openhearth and electric furnaces in the country and you get some idea of the astounding savings made. Chemistry should be proud to have had such a major part in the tremendous increase in steel capacity in our country.

Moving now to the area No. 2, we find that one way the minimum weight objective for Space Age vehicles is being obtained is with the new application of an old chemical process called etching. This has also been known over the years as photo engraving and electropolishing but it comes down to one thing—using a chemical to eat away metal where you want it removed.

Many of the parts in supersonic aircraft and missiles are of irregular shape and are stamped or fabricated from flat plates. These are such parts as doors, bulkheads and wing spars. Large areas on each part are not needed for strength. In engines, castings and forgings sometimes must be made with more wall thickness than is necessary for strength. As all such parts are of irregular shape, it would be extremely costly to machine away the unneeded metal by conventional machining methods. Chemicals can do the job much better and much less expensively.

The chemicals used depend on the material to be machined:

Material	*Major Chemical*
Aluminum	Sodium Hydroxide
Titanium	Nitric Acid plus Hydrochloric Acid
Magnesium	Sulphuric Acid
Stainless Steel	Nitric Acid plus Hydrochloric Acid
Super Alloys	Ferric Chloride

The procedure is quite simple. The part is cleaned and a mask of neoprene is applied. The mask is baked on and then cut away where we want metal removed. The masked part is dunked in the chemical. The depth of cut is controlled by the time of immersion. Removal rates vary from .002″ per minute for steel to .001″ per minute for

aluminum. When the etching is finished, the part is washed, the mask removed and the part is inspected.

The procedure is approximately 3 years old and is developing at a phenomenal rate. Over 40 companies are in the business already. It is an additional tool to supplement the metalworking industry and was taken directly from industrial chemical laboratories.

Area No. 3 brings us again to the theme of my opening story—the solving of the re-entry heat problem for missile nose cones through the use of reinforced plastics. A few Sundays ago on the General Electric Theater on television a nose cone was shown in the commercial. It was interesting to see but unfortunately it was not disclosed that this nose cone was made of plastic, although this information had been printed in various technical journals. The problem comes about when a missile warhead tries to re-enter the atmosphere at a speed of 15,000 to 25,000 feet per second. The impact generates a temperature on the nose cone of roughly 12,000°F.! This is higher than the melting point of any chemical element; the highest ones, tungsten and carbon, being between 6,000°F. and 6,500°F. Many metals have been tried in efforts to solve this problem. They have tried metals in combination with designs incorporating heat sink, sweat cooling, and internal cooling—and none of these attempts have been successful.

The solving of this problem through the use of plastics reminds me of the situation some years back when a group of scientists were trying to develop an oil which could be used in engines with extremely high pressure bearing loads. They had tried adding to the oil any and all of the materials which made any sense. None of them was successful. What is the most undesirable ingredient in lubricating oil? The answer was very obvious—sulfur. Industry had always refined oil to eliminate sulfur completely. So, instead of taking out the sulfur, they dumped in lots of sulfur, ***and the problem was solved.***

Here was a situation where similarly nothing they tried that made sense was successful. Somebody apparently suggested trying something that didn't make sense. Most plastics become soft at a very low temperature. How could anyone imagine that such a material could be used successfully at thousands of degrees of temperature?

Plastics have been flooding from the chemical laboratories of the country. One authority says that in reinforced plastics alone, there are over a hundred thousand variations. To quote Mr. C. A. Hockwalt of Monsanto Chemical Company, in *The Scientific Monthly*, "Polymerization and condensation reactions have produced dozens of new polymers, co-polymers and resins. They run the gamut of properties formerly possessed only by diverse materials found in nature. They offer transparency, lightness, insulating properties, controlled flexural strength and impact strength. They can be hard, flexible or elastomeric."

The scientists who had the idea of trying a plastic to solve the nose cone problem selected a reinforced organic polymer which incorporates quartz fibers for reinforcement. This material could be easily fabricated and they anticipated that it would *ablate evenly*. There is the key! Actually, for its weight, plastic is very strong up to high temperatures *for short times*. Some will withstand 5,000–6,000°F. for several minutes. All that was needed was a material which would absorb heat and protect the payload until the warhead could be slowed down enough to stop the excessive heat generation. This principle of ablation (or disintegration) is based on the occurrence of phase changes which absorb heat—decomposition and sublimation. As the plastic material changes from solid to liquid and from liquid to gas each change absorbs heat and keeps the heat from going through the plastic into the payload underneath. The plastic material disintegrates evenly and disappears but the cone is made several inches thick, thick enough to accomplish its assignment and keep its shape. Here is a real triumph for chemistry over a Space Age problem.

Area No. 4 is concerned with the improvement of metal properties through the use of a strange, exotic group of elements known as the rare earths, the strangers of the periodic table. The rare earths generally refer to 15 chemically similar elements which, on the latest periodic table, are known as the lanthanide series. In popular usage however, there are several more which are coupled with them—scandium, yttrium and thorium. Actually element No. 90, thorium, is the first of a group now called the actinide series of rare earths which form the final ones in the periodic table and include those man-made by atomic bombardment.

I looked up the rare earths in my son's high school chemistry book published in 1958. I was interested to see with what importance they might be treated. I found them *only mentioned as elements*. No reference was made to their importance or their uses. Actually the name "the rare earths" came from the fact that medieval chemists were unable to separate them because they are too similar chemically. The scarcest rare earth is really more plentiful than silver. In the refining of monasite sand to obtain thorium for use in atomic reactors, the rare earths are by-products and are piling up in tremendous quantities. Industry is putting forth tremendous efforts to find uses for these elements. They are never found as pure metals and they are never found as pure ores. The mixture of all the 15 together is known as misch metal and many uses have been found for this material to be used directly.

Today's chemists have not made much advance over the medieval chemists in their ability to readily separate the individual rare earths. One method used is to cool a saturated solution of rare earth salts and

allow each of the elements to crystallize out one at a time. This, of course, is very time consuming and costly. Another method uses fractional distillation and I found a record where one series had been run through 40,000 times. The most recent procedure referenced in the literature consists of trickling a mixture of rare earths dissolved in acid through an ion exchange column filled with synthetic resins. Each takes a different time to flow through and can be collected separately at the bottom.

Regardless of the method used, it might interest you to know that misch metal, as a material, is sold for approximately $3.00 a pound. Some of the individual elements which are separated out and collected pure by one of the above methods, are priced at $10,000 to $15,000 a pound. Obviously, industry is waiting for the chemists to come up with some simpler, less expensive method of separating these elements.

How are rare earths used? For one thing, they are always used a pinch at a time. In recent years many uses have been found for them. In the metal industry they are used for alloying, strengthening, and scavenging undesirable elements. In electronics they are used to coat television screens, in vacuum tubes, capacitors and amplifiers. They are used for coatings such as vitreous enamels and are used in glass for coloration and strength. The glass used to watch atomic reaction has cerium in it to protect the personnel. They are used in the chemical industry as catalysts and oxidizing agents. They are used for protecting the fibers in the textile industry, in paints as driers and opacifiers. In the electrical industry they are becoming widely used for cell anodes, magnetic cores, rectifiers and arc lighting carbons and in ceramics we see their use in coloration and glazes. Most important of all they are becoming very widely used in nuclear research for radiation shields, control rods (gladolinium is replacing hafnium for this as it actually has the best neutron cross section of any element). The element thulium is used in portable X-ray machines. Misch metal is used in cigarette lighter flints. Some of the rarer elements have been found to be super conductors, supermagnetic at extremely low temperatures, near absolute zero. This is an extremely interesting new property to scientists. Rare earths are used in components for microwave transmission—another important part of television receiving.

Let's get around to my original premise, the use of rare earth addition to improve metal properties. Magnesium is a very desirable metal for air vehicles because it is extremely light. Its big drawback is that it loses its strength rapidly as temperature increases. One alloy which has a tensile strength of 40,000 psi at 70°F., has dropped to 6,000 psi at 600°F. (Figure 1). When a 2.5–4.0% addition of rare earth is made, the strength at 500°F. is nearly doubled. When 2.5–4.0% of thorium

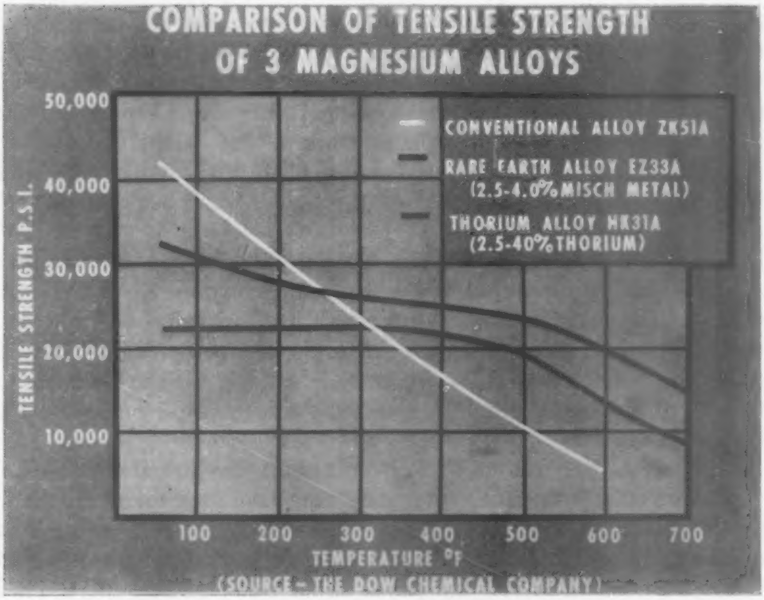

Fig. 1

is added instead of rare earth, the alloy is twice as strong at 600°F. as the conventional one was at 500°F.

From the picture I have painted for you, it should be easy to see where there is a wide open field for chemistry to find more new uses for the rare earths and to find new methods for their separation. A real frontier for exploration.

Area No. 5 delves into the exciting future of the glamour element—Boron. Again I referred to my son's 1958 chemistry book and found the phrase, "little commercial value" written about Boron. The text mentioned borax, the ore from which Boron is extracted. It is mined in the deserts of Nevada and California. Chemically it is sodium tetraborate and is used directly to soften water, and in welding flux. The book also referred to boric acid, a mild antiseptic, to borozon, a boron carbide, which is next to a diamond in hardness and is finding a number of industrial uses, and to pyrex glass, a boron-silicate, which has heat resistant properties. This completed the list.

Actually this list doesn't begin to do justice to the present uses of Boron or to the future possibilities. It is used by glass and ceramic makers; it is used in flame retardant chemicals, in adhesives, in pesticides, in fuses for rockets, in control rods, atomic shields and atomic reactors, in making refractory compounds, in cleaning compounds and in resins. Quite a list beyond that which the chemistry book had.

During World War II Boron was found to have a particularly important and attractive property. It was used in steel production to save alloying elements. A minute pinch of Boron added to the heat would replace hundreds of pounds of nickel, chromium, molybdenum and manganese. It literally saved hundreds of times its own weight in alloying metals. Why? Because as little as one-thousandths of 1 per cent enormously increases the hardenability of steel. The Boron steels of World War II were a major factor in our war production effort.

Now Boron is coming to the fore in a new field—high energy fuels. It is a major ingredient in the mixtures making up both solid and liquid propellants. Its use increases the energy from jet fuels, allowing them to give up to 40% more thrust. Of course there are problems. The Boron hydrides, which are used in high energy fuels, are both poisonous and unstable but the prize is worth the battle. Boron multiplies the energy. When you burn a gram of coal carbon you get 8,000 calories. When you burn a gram of pure Boron you get 4,000 calories. This indicates 6,000 calories should result from burning a gram of a 50–50 mixture. But when you burn a gram of diborine B2H6 the resulting 16,000 calories gives you an indication of the multiplication effect of Boron!

Coming close to home, one of the limitations on the delivery of useful power from a jet engine is temperature, as it affects the strength of the materials used in the engine. If the strength of the materials can be increased so that they may be operated at higher temperatures, the power output can be increased substantially. Small additions of Boron can accomplish this in the super alloys used in the combustion and turbine sections of the engine. Figure 2 shows what the addition of five hundredths of one per cent Boron to a super alloy did to its strength. As you can see it increased its tensile strength 37% at 1,200°F. All the other percentages of the alloying elements in these two super alloys remained identically the same. A truly remarkable property of the glamour element!

The research on Boron by the chemical industry is very high. The armed services are, of course, supporting much of this. Almost limitless markets for Boron could be won if research could solve some of the basic problems of Boron chemistry. Here again is another fertile field for the present and future chemists of this country.

I have covered five areas where chemistry is playing a major role in the Space Age that is on us. We stand on the frontier of technological development in many areas. The rate of progress is actually staggering. A year ago I can remember making the statement that there was no alloy of titanium which was strong enough to be useful beyond 700°F. Just last week I picked up a trade paper in which it

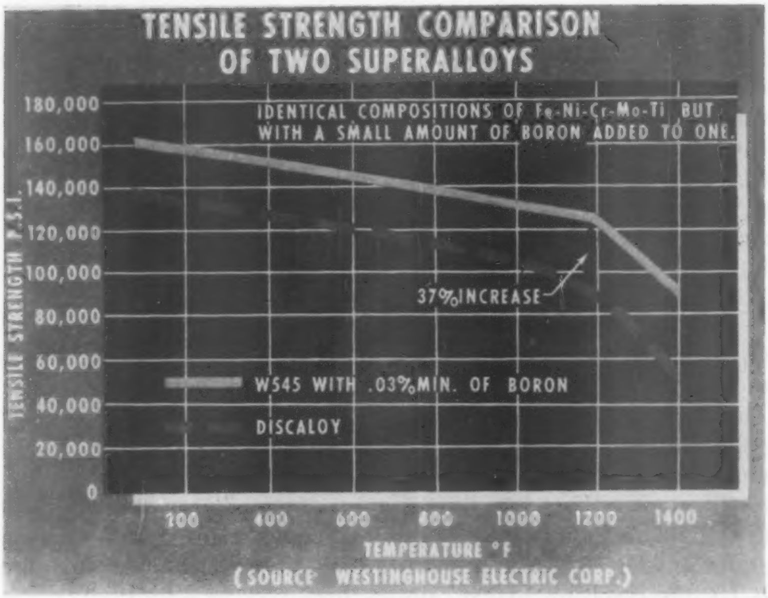

FIG. 2

was stated that a development laboratory was ready to announce a titanium alloy which has adequate strength up to 1,100°F! A 400°F. improvement in one year! Another major step in producing a light and strong alloy to help in Space Age vehicle production.

To quickly summarize, chemistry has played a major part:

1. In *steel production* by providing rapid, accurate control of carbon content of steel heats so that industry can produce large quantities of high quality steel.
2. In *machining with chemicals*, the infant industry in which weight reduction is obtained by directly removing material through chemical action.
3. In the big boost given to the *plastic* industry when it was found that plastics provided the answer to the Space Age nose cone re-entry problem.
4. In the increasing importance of the *rare earth* elements as the problems of separation are solved and new properties are determined.
5. In the many, many uses to which the relatively unknown element *Boron* is being put solving problems in the nuclear and Space Age areas.

Chemistry's role is one of constantly increasing importance. The illustrative material I have given should help you convince your students of this. Text books can't cover everything. They sometimes miss covering an important function of chemistry—as in the steel industry. New uses for old processes are constantly being introduced—as in chemical machining. New materials are being invented to answer new problems—as with plastics. The Periodic Table will never

cease to be a source of new materials with new properties—as with the Rare Earths and Boron. By using illustrative material which comes directly from the frontiers of development we can make chemistry's role more vital to all the students, even those who do not plan to make it their career. You should be especially proud of your part in developing present and future chemists and chemical engineers.

SCIENTIST PERFECTS ELECTRICAL ARTIFICIAL NERVE CELL

A simple electronic device that can become fatigued and react in other ways similar to a tiny living nerve cell in the human eye and ear has been constructed by scientists at the Bell Telephone Laboratories. But the similarities to real biological nerves are at best vague and approximate.

The inexpensive electronic cell is mounted on a three-by-four inch printed-circuit card. Using a number of the inexpensive cells, research men have recently begun attempts to follow nature further. Cell by cell, they are building electronic systems that imitate some of the simple workings of nerve networks in the eye and ear.

The electrical cell delivers a series of electrical pulses when stimulated, similar to a living cell. It also fails to respond under conditions where a biological cell would not respond, and can show fatigue like a living nerve cell—that is, slow down under prolonged stimulation.

COSMIC RAYS AND SOLAR PARTICLES CAUSE EARTH'S RADIATION BELTS

Sun particles and cosmic rays are the different causes of the earth's two distinct radiation belts which threaten man's voyages into space.

The outer or "soft" radiation belt, centered some 20,000 miles in space above the equator, is caused by particles from the sun. The second one, called the "hard" radiation belt, is centered about 2,000 miles out and results from cosmic rays smashing into the earth's atmosphere.

It is believed that each belt seems to resemble a giant, invisible "doughnut," deformed to follow the earth's lines of force.

The outer one is considerably more pushed out of shape than the inner belt, but the effect is to give both a set of "horns" turned in toward the earth and centered above the auroral zones in each hemisphere.

It has been suggested that a satellite or rocket with a 500-pound payload could be used to inject artificially accelerated particles into the radiation belt region, thus testing experimentally the theory concerning the origin and distribution in space.

The best place for such an experiment with a small linear accelerator of electrons would be from 600 to 1,000 miles above the equator. Particles injected with energies of 2,000,000 electron volts would rapidly spread out within the radiation belt doughnut.

This diffusion would require only a few seconds since the particles move with nearly the speed of light. The particles would then, however, remain trapped within the doughnut, diffusing out of it very slowly.

By studying the number of remaining electrons from day to day, scientists could learn about the density of the atmosphere in a region of space where densities are normally not measured.

How Can We Show Parallax?

Marvin J. Pryor*

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"I'll be glad to set up a demonstration in the hall" was my answer to the title-question after an oral discussion without equipment was unsatisfactory. Representative high school science teachers, fellows at the National Science Foundation Institute at the University of Connecticut, were so appreciative of the hall-demonstrations that I am encouraged to draw figures of the equipment these teachers used and describe the procedure for you.

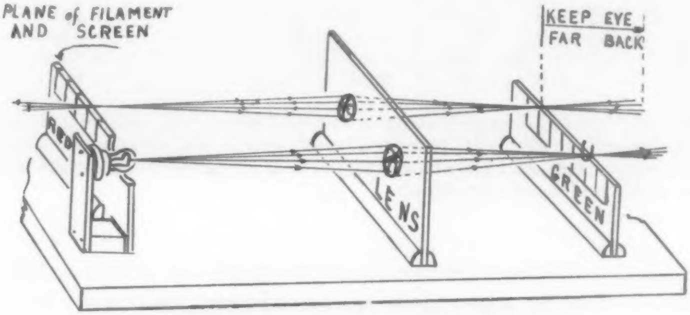

FIG. 1. Locating a real image by parallax.

FIGURE 1 SHOWS A METHOD OF LOCATING A REAL IMAGE BY PARALLAX. The screens are made by folding red and green graph paper so as to show lines on both sides and tacking them to small boards. The positive lens (or two identical lenses) may have a 15 or 25 cm focal length. The 10 watt lamp has a clear bulb and a "C" shape filament in a plane. The tops of the screens and the centers of lens and lamp should all be at the same height. The distances of separation are adjusted until a sharp image of about half the filament appears on the image screen, the screen that has green lines. Now, get far back in line with the system and look straight toward the lamp. You should see the part of the image which is above the screen. In Figure 1 it is the up-turned images of the ends of the filament that in the lamp are pointing down. We could now study parallax, but the light is too bright. Exchange the lamp filament for the screen with red lines. (Just move to one side if you use two lenses.) Images of part

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* National Science Foundation Faculty Fellow, Summer 1958.

of the red lines are made on the green screen with part extending above it as drawn for the lamp. However the image on the screen can not be seen for they are too faint. Look as if along the rays represented in Figure 1 and you should see red lines above the green screen. It is helpful to stand back and vary your eye level. A test is made by a slight sidewise eye motion. The red lines of the image should not move relative to the lines on the green screen. Now go behind the red screen at the other end. You should see images of the green lines above the red lines. By this alteration you have exchanged object and image. Now move the green screen away from you toward the lens. Then, as you move to the right or left the green lines will seem to move with you past the red lines. This is because the green lines are farther away from you than the red-line images are.

If the screen is placed too close to you, the nearer green lines go past the red ones in a direction opposite to your motion. (Since the lens is far beyond both sets of lines you are looking at, you can see the lines move rapidly past the lens.) Concentrate on the lines, now, and move the screen to the position which again shows no parallax between the images of red lines and the actual green lines. Check the accuracy of your work by looking from the other end. This arrangement serves to locate real images—images that could be seen on a screen were they bright enough. You may replace the lamp for a re-check, but after a few trials you will be perfectly satisfied with the accuracy of the parallax method of using the two screens.

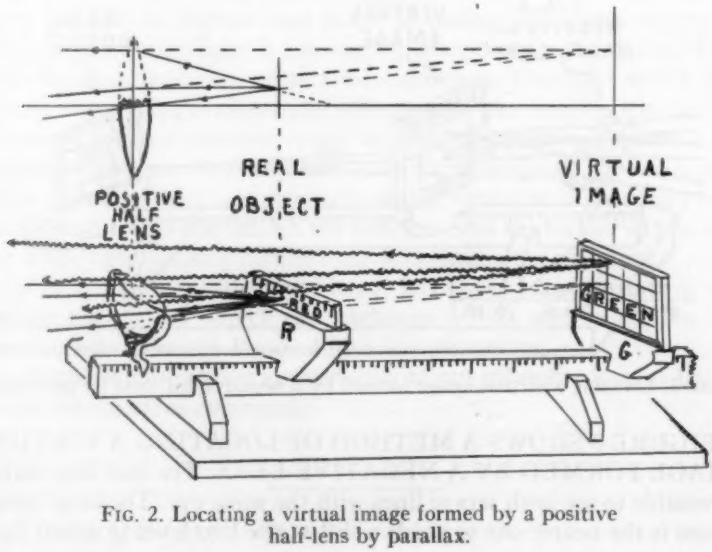

FIG. 2. Locating a virtual image formed by a positive half-lens by parallax.

THE ARRANGEMENT IN FIGURE 2 IS USED TO LOCATE A VIRTUAL IMAGE BY PARALLAX. Reflected light from each point on the red screen R, which is closer than the principal focal point, converges enough that it seems to come from a more distant point. The wiggle lines on Figure 2 show rays from the same distance as the rays from the half lens. Equipment like that in Figure 1 may be used excepting that you should run a glass cutter along a diameter of the lens and tap it gently until you have two half lenses. Eye-center, half-lens-top and the top of the red screen R should be in a plane that cuts the green screen G. You see an enlarged image of the red lines by light that comes through the lens and enters the lower half of the pupil of your eye, and a green image of light that misses the lens and enters the upper half of the pupil of the same eye.

Ordinarily you will see a motion of the red lines relative to the lines on the green screen when your eye is moved parallel to the lens' edge. The more distant lines move the same way your eye does, relative to the nearer lines. Slide the screen nearest you until there is no relative motion. As related to the half-lens, the red screen is the object and the green screen is at the position of the red image. By this procedure a virtual image is located by parallax for a positive lens.

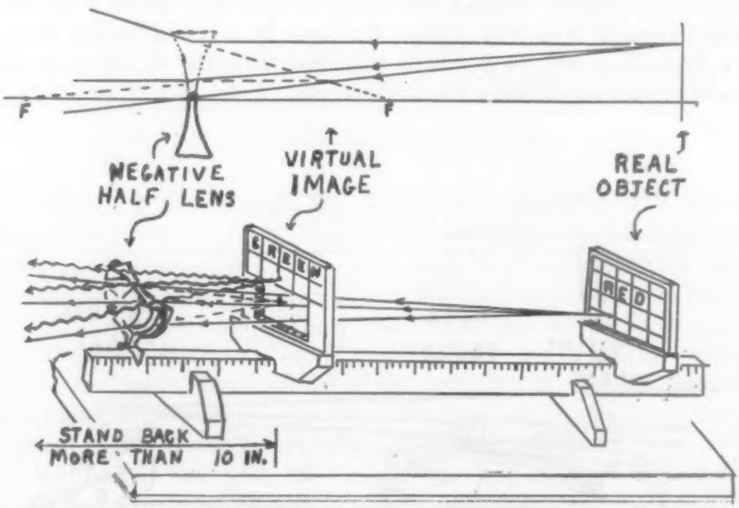

FIG. 3. Locating a virtual image formed by a negative half-lens by parallax.

FIGURE 3 SHOWS A METHOD OF LOCATING A VIRTUAL IMAGE FORMED BY A NEGATIVE LENS. The half-lens makes it possible to see both sets of lines with the same eye. The large image screen is the nearer one so needs a slot at the lens level to admit light

from the red screen. You must stay back at least 10 in. (25 cm) from the image screen in order to see it clearly. The procedure regarding Figure 2 may be followed, as given above, in other respects.

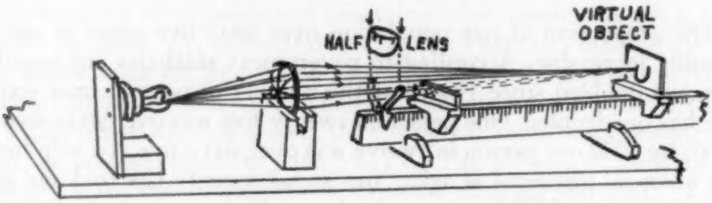

FIG. 4. A virtual object for the positive half-lens.

Virtual objects can easily be represented with the equipment discussed. In Figure 4 the apparatus of Figure 2 is assumed to be in adjustment so that there is no parallax between images of the red lines and the green lines. The positive half-lens is removed or covered. The lamp and another positive lens are placed so that light passes through the lens holder and strikes both the red and green screen. Adjust the positions of the lamp and whole lens until a focused image is on the green screen. Replace the half-lens. Now a good image is focused on the red screen. The light from a point of the filament is incident on the half-lens but it is converging toward a point on the green screen. Note the difference. Light spreads from a point to the whole lens. The lamp is a real object. Light incident on a lens is related to the object. Light incident on the half-lens is not spreading, but is converging. A point to which this light is converging is a point on the object. This type of object is spoken of as a virtual object. The light which was already converging is converged still more by the positive lens and so focuses at a closer position—right on the red screen as originally set by the parallax method. You now have a real image on the red screen where the real object was originally and a virtual object on the green screen. Light that still misses the half-lens still shows the virtual object while light passing through the lens makes the real image.

By this procedure object and image have been exchanged. You can represent a virtual object and exchange object and image for the negative lens shown in Figure 3 by a like procedure.

I should like to express appreciation to my colleague Robert Lanni for his constructive comments.

Evaluation of Pensions

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University of Arizona, Tucson, Arizona

The proportion of our population over sixty-five years of age is steadily increasing. According to government statistics our population has doubled since 1900, but the number of persons over sixty-five has quadrupled. One person in twenty-five was over sixty-five in 1900; by 1952 one person in twelve was over sixty-five. To help meet the financial problems of aging, our social security law (old age survivorship insurance) was passed, also an increasing number of employers are instituting pension plans for their employees, and pensions are being sold by insurance companies. Hence the evaluation of pensions may be of some general interest. For such evaluation actuarial science uses, in some cases, an interesting, even remarkable, result called the law of uniform seniority. The following discussion offers an explanation of the evaluation of pensions including this law. It is intended for the general reader who remembers a few elementary facts from the theory of probability and from the first year of calculus. No knowledge of actuarial mathematics is assumed.

The amount A of a principal of P dollars accumulated for n years at the rate of interest i compounded annually is given by $A=P(1+i)^n$. P is also called the present value of A and equals $A(1+i)^{-n}$. It will be convenient to represent $(1+i)^{-1}$ by v and write $P=Av^n$. Also for our purpose a mortality table is needed. Such a table shows, in a column headed l_x, the number of persons surviving at each integral age x out of a large number l_0 of persons born alive.

While pensions are commonly paid at the beginning of each month, we shall consider them, for the sake of greater simplicity, as being paid at the beginning of each year. This method of payment is regularly treated first and then modified to take care of monthly installments. The symbol (x) is used to represent a person aged x. The symbol $\ddot{a}_x$ represents the present value of a pension, or life annuity, of \$1 paid at the beginning of each year as long as (x) survives. The symbol $\ddot{a}_{xy}$ represents the present value of \$1 paid at the beginning of each year as long as both (x) and (y) survive. In order to evaluate $\ddot{a}_{xy}$, we shall use the law of uniform seniority. Because $\ddot{a}_{xy}$ represents a form of life annuity which is not very practical, we shall use $\ddot{a}_{xy}$ together with $\ddot{a}_x$, to evaluate an annuity of much more practical importance. This latter is called a joint and survivor annuity whose present value is represented by $\ddot{a}_{\overline{xy}}$. It pays \$1 at the beginning of each year as long as either (x) or (y) survive. Such an annuity might well be purchased by a man and wife to furnish them income as long as either shall live.

In evaluating contingent benefits, such as life annuities and insurances, it is assumed the group of annuitants or policyholders in question experiences the same mortality as the l_0 persons in the mortality table. In other words the present value, or cost, of the benefit is calculated for the l_x persons of this table. Now consider $\ddot{a}_x$. Of l_x persons now alive, l_{x+t} will survive t years. Then l_{x+t} dollars will be needed to make the $1 pension payment due at the end of t years to each of these l_{x+t} survivors. These l_{x+t} dollars have a present value of $v^t l_{x+t}$, which divided among the l_x original annuitants, makes the cost, or present value, to each $v^t l_{x+t}/l_x$. The present value $\ddot{a}_x$ of an annuity is the sum of the present values of all of its payments. Hence

$$\ddot{a}_x = \sum_{t=0}^{\infty} v^t l_{x+t}/l_x. \tag{1}$$

Here ∞ is used as a convenient upper limit to indicate that the summation continues until all of the lives involved have vanished. For any given mortality table and for any given rate of interest (1) may be calculated and tabulated for all values of x. The mortality table most commonly used to evaluate annuities[1] has 109 as the oldest age. Hence $\ddot{a}_x$ would have 110 values making a table that would not be especially long or cumbersome to handle. It should be noted at this point that we may write $l_{x+t}/l_x = {}_tp_x$, where ${}_tp_x$ is the statistical probability that (x) survives t years. Hence (1) may be written

$$\ddot{a}_x = \sum_{t=0}^{\infty} v^t \cdot {}_tp_x. \tag{2}$$

Next consider $\ddot{a}_{xy}$. We may think of (xy) as a sort of joint life so-called, i.e., as a single entity that survives or fails. Then (xy) survives if both (x) and (y) survive; (xy) fails if either (x) or (y) fails or both fail. From this point of view, we may write, using (2),

$$\ddot{a}_{xy} = \sum_{t=0}^{\infty} v^t \cdot {}_tp_{xy} \tag{3}$$

where ${}_tp_{xy}$ is the probability that (xy) survives t years. By the multiplication theorem of probability

$${}_tp_{xy} = {}_tp_x \cdot {}_tp_y = (l_{x+t}/l_x)(l_{y+t}/l_y)$$

so that (3) may be calculated and tabulated for all values of both x and y. However, there would be 6105 pairs of ages (including equal ages) from age zero to age one hundred and nine making a rather large table. If several rates of interest are also supplied, the resulting tables would become very extensive. It is here that the law of uniform

[1] 1937 Standard Annuity Table—2½% Interest.

seniority comes to our aid reducing very greatly the size of our tables.

We now turn to the law of uniform seniority. In order to derive this law, we need to think of l_x as a continuous and differentiable function of x. Then dl_x/dx is the instantaneous rate of change of l_x per year of age. For example, from a certain mortality table[2] we find

$$[dl_x/dx]_{x=30} = -241 \text{ lives per annum} = 241 \text{ deaths per annum},$$

since l_x is reduced by deaths. These deaths occur among $l_{30} = 90092$ lives, therefore

$$[(-dl_x/dx)/l_x]_{x=30} = 241/90092 = 0.00273$$

is called a death rate. As long ago as 1825 an English actuary, Benjamin Gompertz, suggested that this death rate $(-dl_x/dx)/l_x$ might be composed of two parts, one part fairly constant throughout life and due to liability to accident and infectious disease, and another part consisting of disability which increases with age at a rate proportional to itself, i.e., disability growing according to the compound interest or snowball law so common in nature. Accepting Gompertz's hypothesis, we are able to write

$$(-dl_x/dx)/l_x = A + Bc^x,$$

where A, B, c are constants. Then

$$-\ln l_x = Ax + (Bc^x/\ln c) - \ln k,$$

or

$$l_x = ke^{-Ax} \cdot e^{-Bc^x/\ln c} = ks^x g^{c^x}, \tag{4}$$

where

$$e^{-A} = s, \quad \text{and} \quad e^{-B/\ln c} = g.$$

Equation (4) is the Gompertz-Makeham law of mortality. With the proper choice of k, s, g, c, it is found to fit very satisfactorily many of the most important mortality tables from about age twenty to the end of life. We shall use (4) to evaluate (3). Let x be the younger of the two ages x and y so that $x+n=y$. We find first

$${}_tp_x = l_{x+t}/l_x = ks^{x+t}g^{c^{x+t}}/ks^x g^{c^x} = s^t g^{c^x(c^t-1)}.$$

Similarly

$${}_tp_y = {}_tp_{x+n} = l_{x+n+t}/l_{x+n} = s^t g^{c^{x+n}(c^t-1)}.$$

Then

[2] Mortality Table for U. S. White Males 1939–41.

$$ {}_tp_{xy} = {}_tp_x \cdot {}_tp_y = s^{2t} g^{c^x (c^t - 1)(c^n + 1)}. \tag{5} $$

We now try to choose $x+r$ (called the equivalent equal age) so that

$$ {}_tp_{x+r:x+r} = {}_tP_{xy} $$

for all values of t. If this can be done then the 4095 values of ${}_xP_{xy}$ for ages 20 to 109 can be replaced by 90 corresponding values of ${}_tp_{x+r:x+r}$. Again using (4),

$$ {}_tp_{x+r:x+r} = ({}_tp_{x+r})^2 = \left[s^t g^{c^{x+r}(c^t-1)}\right]^2 = s^{2t} g^{2c^{x+r}(c^t-1)}, $$

which must equal.
This will follow if

$$ 2c^{x+r}(c^t-1) = c^x(c^t-1)(c^n+1). $$

Dividing out $c^x(c^t-1)$, we have $2c^r = c^n + 1$, or

$$ r = \frac{\log (c^n+1) - \log 2}{\log c} \tag{6} $$

from which it is seen that r depends only on the seniority n of y over x and does not depend upon x itself. In other words, r is the same for all pairs of ages x, y where the seniority between them is the same or is uniform. This fact is called the law of uniform seniority. The constant c depends on the mortality table being used, and n may take only positive integral values. Hence, using (6), a table of values of r (addition to younger age) for given seniorities n may be constructed. This, with a table of $\ddot{a}_{xx}$ for equal ages, will enable us to evaluate $\ddot{a}_{xy}$ for any pair of unequal ages.[3] Of course, the values of r are not integers so that when the equivalent equal age $x+r$ has been found, it is needed to interpolate in the a_{xx} table.

Returning at last to the evaluation of the joint and survivor annuity $\ddot{a}_{\overline{xy}}$ which was mentioned near the beginning, it is readily seen that

(7) $$ \ddot{a}_{\overline{xy}} = \ddot{a}_x + \ddot{a}_y - \ddot{a}_{xy}. \tag{7} $$

For if (x) and (y) are both living on any date when an annuity payment is due, then the right member of (7) yields $1+$1-$1=$1. If (x) is living and (y) is dead, then this right member yields $1+0-0=$1. Finally, if (x) is dead and (y) living, the yield is 0+$1-0=$1. Hence (7) must be true and can be used to evaluate $\ddot{a}_{\overline{xy}}$. We have been discussing pensions of $1 per annum. One thousand dollars per annum is, of course, worth one thousand times as much as $1 per annum. Likewise, the present value of any amount per annum may be found by multiplying.

[3] For examples of such tables, see Jordan: *Life Contingencies*, p. 294 and p. 297.

As a numerical example, consider the present value of a joint and survivor annuity of $1200 per year to man aged 65 and his wife aged 60. Here the seniority n equals five years. Using tables in the last reference, the addition r to the younger age equals 2.765. Hence the equivalent equal is 62.765. Using linear interpolation between

$$\ddot{a}_{62:62}=8.11113 \quad \text{and} \quad \ddot{a}_{63:63}=7.76562,$$

we find

$$\ddot{a}_{62.765:62.765}=7.84681.$$

Also

$$\ddot{a}_{60}=12.11074 \quad \text{and} \quad \ddot{a}_{65}=10.09689.$$

Then by (7)

$$\ddot{a}_{\overline{60:65}}=12.11074+10.09689-7.84681=14.36082.$$

This last number, multiplied by $1200, gives $17,233 as the present value of the pension in question based on two and one half per cent interest and the Commissioners 1941 Standard Ordinary Mortality Table.

PROPOSE TRAPPING METEORS IN ORBITING SATELLITE

A satellite with a built-in meteor trap to detect the tiny particles of meteoric matter in space has been designed by a scientist.

Dr. Gerald S. Hawkins of Boston University said a satellite meteor-catching system would help in assessing the structural damage that might be caused to man-made vehicles in space. In a special report to the Smithsonian Institution Astrophysical Observatory, where he is a consultant, Dr. Hawkins said the information gathered by a meteor-trapping satellite would also extend the frontiers of meteor astronomy.

The tiny meteor particles cannot now be detected from the earth's surface. Dr. Hawkins estimates his rotating trap would detect about one meteor per day if the collecting area of the microphone were about one and a half square inches. Microphones in satellites have already proved successful for measuring the impact of small meteoric bodies in space.

Dr. Hawkins' method consists of using two rotating cylinders, the outer one with one slit, the inner with two slits. The combination spins about its axis so that only meteors with the correct speed can pass through the system and hit the microphone, which is on the inside edge of the outer cylinder.

STUDY MINERAL RUNOFF FROM LAND

Scientists from 30 countries are studying 65 rivers, which provide 75% of the total runoff to the oceans of minearal matter from rocks and soil. The work has been assigned to a Committee of World-Wide Runoff of Dissolved Solids, appointed from members of the International Association of Scientific Hydrology of the International Union of Geodesy and Geophysics. Water samples are being taken at least four times a year near the mouth of each river at points where natural river turbulence insures representative sampling and where there is no contamination by sea water. Results will be compiled for publication by the U. S. Geological Survey.

Toys and Physics

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The principles of physics envelop us on every hand. In toys they find an inviting and delightful application. Although principally designed for children as a device to play with, the physics is by no means always "child's-play." In this paper we discuss a few toys the physics of which is an exciting inquiry.

Introduction: The place of toys in modern society needs no recitation. Indeed, there is evidence historical and archaeological that toys have occupied a place in all of human history. This is to be expected, of course, since the fundamental nature of human kind has experienced no metamorphosis. Children have always been children. But all facets of human affairs have experienced the impact of ever-enlarging and ever-encompassing *applications* of physical laws and physical principles. And so it is with toys. As with the other machines and gadgets of our age which have become complicated, the fundamental, immutable principles of physics remain inherent and unchanged. The conditions of equilibrium for a rigid body have suffered no changes since the days of the Pyramid builders. Momentum conservation is as good today as in Hero's time. The immutable principle that the energy of a system tends toward a minimum still holds although it may lie concealed in an intricate device. A rotating body still tends to rotation about an axis for which the moment of inertia is a maximum. The electrostatic behavior of bodies is as good today as in the time of Thales, although we now have materials in which the effects reside longer.

The title of this paper is synonymous with its purpose. We have examined a great many toys and we report on a few which possess special virtues—special in the sense that they are intriguing.

"The Fall Guy"—A Mechanical Toy

This toy, which goes by the name of "The Fall Guy," is a rigid plastic figure of a man in evening clothes and tall hat about 4 inches high. His left hand clutches the classical "bottle" while his right searches for his door key! ***He is slightly stooped forward.*** Adhering to type he cannot, in general, stand erect on his feet. If placed so he at once falls over and ***always backwards.*** This suggests that a plumb line through his center of mass falls ***behind*** his heels. But he can be made to stand, at least for a few seconds. And if one slyly accomplishes this must it not follow that his center of mass was urged forward? Since his frame is rigid there obviously must be some mass ***within*** him whose position can be changed, and indeed this is so. Recall now that he stoops forward. Does this suggest the solution?

Fig. 1. "The Fall Guy."

To stand him on his feet then, he must first be held upside down for a minute or so. This is surreptitiously done in the hand or in your pocket. (I carry him in my pocket upside-down, which always readies him for the trick!) Or he can be given an impulsive motion like that of shaking down a clinical thermometer. The free-moving mass within him gravitates to his head which is in a plumb line with the soles of his feet. If, now, he is put on his feet the internal mass gravitates slowly to his posterior end whereupon, in a few seconds, he falls.

I have "pulled" this on a goodly number of people, including physics professors, and the results are astonishing. Get one and try it.

The "Centrifugal" Force Dilemma

It is absolutely surprising what a dilemma this toy produces. A plastic semi-circular trough (quite like an old-fashioned watering trough) about 3″ long and an inch wide has a recess or shelf on each end at the upper edge. Two tiny steel spheres reside in the bottom of the trough. There is a vertical partition between them, normal to the long axis of the trough. The trough is closed with a clear plastic cover across the top. The problem is to get one sphere in each recess or pocket.

It is not so obvious that no amount of juggling can accomplish this,

and most experimenters give up. But the problem is really elementary. A quick rotation about a vertical axis through the center of the gadget accomplishes it in a stroke. I suppose we must call it "centrifugal" force for the unsophisticated! One must be careful to state that *no accessories are permitted.* A student did it smartly with his magnetized pocket knife!

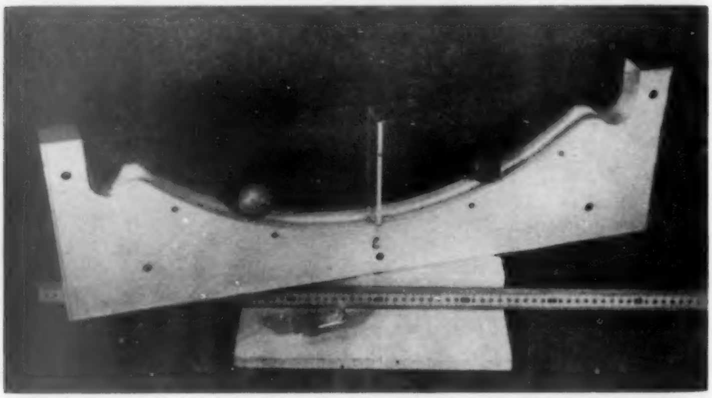

FIG. 2. The "Centrifugal" Force Dilemma.

On a large scale this makes a good lecture demonstration, and we have built one nearly a meter long, mounted on a vertical shaft to permit rotation, and with wooden spheres 2" in diameter.

ROCKET MISSILE—A MECHANICAL TOY

This toy is a ***real rocket-propelled missile.*** It is a precision-built device made of butyrate plastic about 8" long and 2" across at the midsection, rocket-shaped and equipped with tail fins. The tail end has a quarter-inch orifice. The vehicle is filled about one-third full with water. A hand pump fits over the tail-end orifice and locks on with a sliding sleeve. Some 15–20 pump strokes of the pump completes the "fueling." The rocket is now held skyward and the locking sleeve pulled free. The rush of water outward and downward sends the rocket some 300 feet or more into the air. If fired horizontally from shoulder height it has a range of 100 feet or more. These observations suggest a take-off velocity of about 150 ft/sec.

The fuel components are variable in amount; the more water the less air. Also, the efflux velocity of the water is governed by the pressure built up in the vehicle with the hand pump. And too large a fuel load (water) defeats the take-off velocity.

In flight it is mechanically stable. It spins clockwise about its long

axis, the spin direction being governed by the tail-fin orientation. Two of the tail-fins (there are four) permit change in pitch which alters the spin velocity as the rocket rises. Its trajectory is beautifully parabolic and it falls nose first.

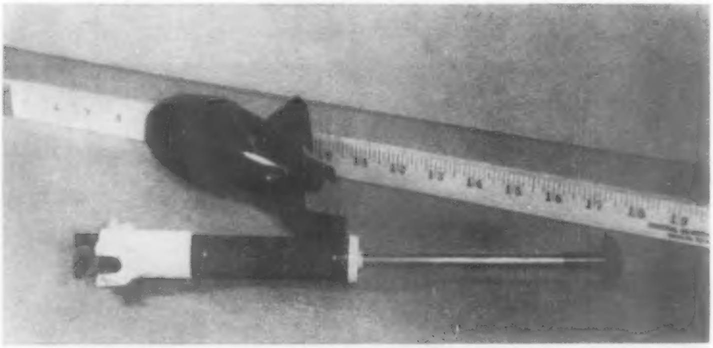

FIG. 3. Rocket Missile.

This gadget lends itself to the classical elegant analysis of rocket flight invoking momentum conservation. Some good questions to ask are: (1) What is the velocity of the rocket when all the fuel is used up? (2) When does the vehicle have maximum efficiency? (3) Can a rocket go faster than its exhaust? It is important to point out in the analysis that the rocket is wasteful of either *power* or *mass*. It cannot be frugal with both. And it is more desirable to save mass rather than energy, which is quite an unexpected observation.

With our minds so given today to rocket flight this toy is a timely one to demonstrate and I know of none so realistic and dramatic.

Helicopter Wheel and Top—A Mechanical Toy

This toy appears in many sizes and has different mechanisms for putting it into rotation but the physical behavior is the same for all. A plastic wheel, 1″ to 6″ in diameter, with nearly all the mass in the edge, has three spokes emanating from the hub and ending in the wheel's edge. The spokes are thin but wide in the plane of the wheel and they are "pitched." The hub has a short hollow shaft on one side of it, normal to the plane of the wheel, and this shaft just fits a spindle which is held vertically in the hand. A light string is wound about the hollow shaft so that when unwound the rotation favors the pitch of the blades. When, now, the free end of the string is pulled, as on a top, the wheel is set into rotation. Some are equipped with a spring and ratchet mechanism for winding up, and the stored spring energy gives the wheel its rotational energy. The angular velocity acquired by the wheel is obviously governed by the length of the

unwinding string and the pull applied to the free end, which is in keeping with Newton's Second Law for rotation and the work done by a torque. If the angular velocity is sufficient the wheel rises from the spindle by the "bite" which the spokes take of the air. It can rise 100′ or more. It is mechanically stable on ascending and descending, even though it glides laterally, and when it lights on the ground it continues to spin on the end of the shaft like a top. If done indoors its spin on a fairly smooth floor or desk top is phenomenally long since its kinetic energy of rotation is quite substantial and the friction torque neglibibly small.

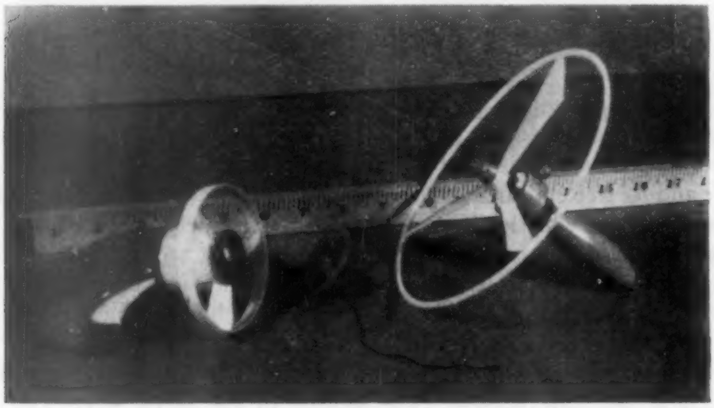

FIG. 4. Helicopter Wheel and Top.

This spinning wheel on the desk top behaves as a rotating symmetrical body and demonstrates beautifully the three motions, ***spin***, ***precession***, and ***nutation***. It can be shown in connection with the analytical treatment of a spinning top.

BIRD CALL FLUTE—AN ACOUSTICAL TOY

A clear-plastic tube about 6″ long and ½″ bore is machined at one end as a whistle. That is, this end is open for blowing by mouth and a slot is appropriately located on the upper edge of the tube a little removed from the blowing orifice. In the hollow tube resides a piston whose position can be changed by pulling and pushing on the "connecting rod." By this operation the length of the resonating column can be readily altered and hence the pitch of the note. The action is like that of a slide trombone. There is a least length of about 2.5″ which can be made to "speak," and the greatest length is about 5.5″. The frequency emitted, therefore, goes from about 1300 vps to about 600 vps for the fundamental aroused by gentle blowing. With excessively hard blowing higher hermonics arise.

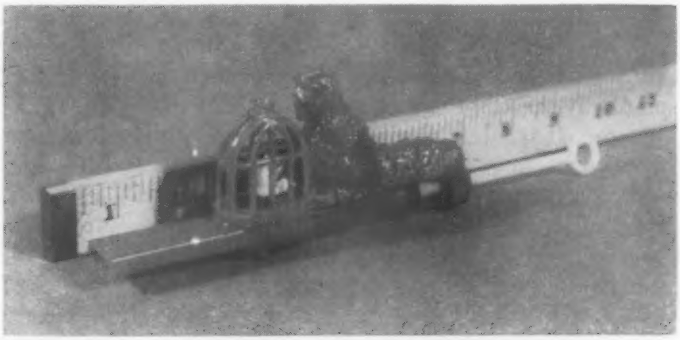

FIG. 5. Bird Call Flute.

Now an interesting and unusual feature of this whistle is the following: A slender phosphor-bronze strip about 2″ long, running parallel to the tube, is fixed at one end on the top of the whistle chamber and its free end, bent at right angles, rests in (projects down into) the slot of the whistle. This metal strip is extremely elastic and strikingly responsive mechanically, and the slightest tremor of the hand imparts vibrations to it. When, now, the whistle is blown, the metal strip is further agitated and the bent end, which lies in the air stream, periodically interrupts the efflux of air from the whistle's slot. The note now heard is not continuous, as it is with the metal strip disengaged, but interrupted. (The motion of the metal sliver can be arrested by holding it still with a match stick.) If allowed to vibrate its amplitude grows by resonant mechanical response to the uniform blowing but the pitch of the now-interrupted note is unaltered. The period of the metal sliver is unaffected by such amplitudes as can be attained. Changes in air pressure, however, achieved by blowing harder or easier, do change the frequency of the metal strip. Such air pressure changes also introduce harmonics.

A variety of musical effects can be gotten by supplying steady air while rapidly sliding the piston or by admitting sharp bursts of air by the valve-like action of the tongue, which is called "tonguing." This last is an important technique in playing wood instruments. Such other effects as chirping, trilling and warbling can also be produced by changing the plane in which the whistle is held while blowing, since this mechanical motion now favors and now opposes the vibration of the metal strip. This is essentially the problem of affecting a periodic motion, say of a supported spring, by motion of the support.

Two such whistles can be sounded simultaneously to show a beat frequency when the pitch of one is altered by sliding the piston or by heating gently (and briefly) with a match.

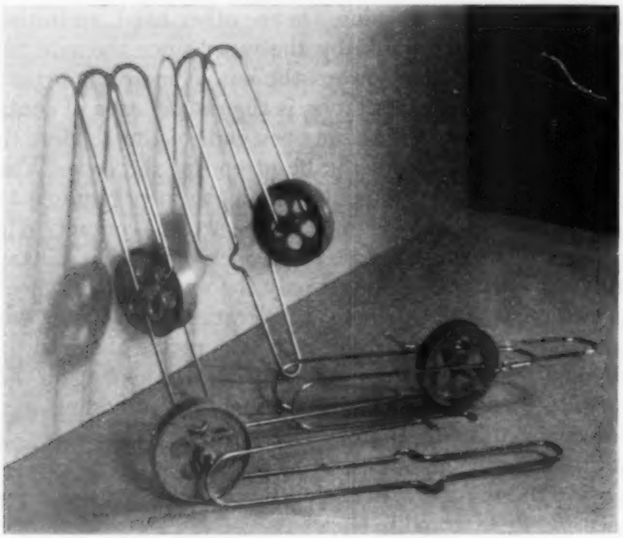

FIG. 6. Maggie Wheel.

MAGGIE WHEEL—A MAGNETIC TOY

This toy consists of a wheel and a U track on which it runs. The wheel is plastic, about 3″ in diameter with a rim $\frac{1}{2}$″ wide. The mass of the wheel is largely in the edge, giving it a large moment of inertia about a normal central axis. A quarter-inch steel axle about 2″ long runs normal to the plane of the wheel. The ends of this axle are tapered to blunt-ended conical shape and the axle is highly magnetized. A heavy iron-wire U about 2″ wide and 10″ long with its straight ends turned back forms a "closed" track on which the wheel rides. That is, the tapered ends of the axle rest on the iron rail. The U track is held in the hand by its lower closed end and rotation is imparted to the wheel by raising and lowering the U frame. If the hand motion is put in phase with the position of the rotating wheel on the track, that is, if these are synchronized, a remarkable angular velocity can be imparted to the wheel. The wheel thus acquires an enormous store of rotational kinetic energy (having large moment of inertia and large angular velocity) and when the hand motion is arrested the wheel continues to traverse the closed track for many trips. Indeed, with the frame held vertically, the stored energy of rotation carries the rotating wheel a dozen or more times up and down the closed loop, now on the inner edge, now on the outer.

A significant physics feature of this gadget is the taper of the magnetized axle. If the initial rotation of the wheel has no wobble (that is, if the motion is all in the plane of the wheel), the taper con-

strains any wobble from ensuing. On the other hand, an initial slight wobble is enhanced many-fold by the taper since the axle "creeps" first toward the right then toward the left. A more important function, however, served by this taper, is the *smaller* area of contact between the axle and the rail at the open ends of the U. Here the contact area is the very edge of the blunt end of the cone. When two surfaces of magnetized iron are in contact the force required to separate them is inversely proportional to the area of contact. When the rotating wheel is on the *outside* of the open end of the U track this magnetic force must overcome not only the weight of the wheel but it must also provide the centripetal acceleration to keep the wheel on the track. Since the velocity is high and the radius of the turn on the rail extremely short this force is substantial. But here again the taper of the axle serves an important function by providing a smaller radius on which the wheel rolls, thus reducing the linear velocity without altering the angular.

Kids using the toy vie with each other in having it make the most trips, once energy is stored in it.

"Der Wunderhund"—A Magnetic Toy

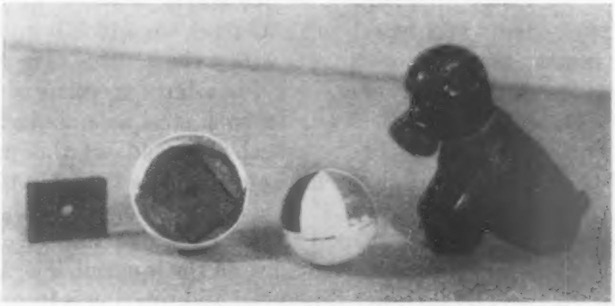

Fig. 7. "Der Wunderhund."

This toy consists of two parts, a thin-walled plastic hollow ball about the size of a ping-pong ball, and a plastic dog some 3 or 4 times larger than the ball. The dog sits on his haunches with his front legs vertical and close together. The ball is loaded in the bottom of one hemisphere so that it is always in stable equilibrium. If slightly tipped it returns at once to the configuration for which its energy is a minimum.

If, now, the dog is pushed face forward toward the ball, sliding his feet on the table top (that is, he is not lifted above the surface on which they both reside) the ball goes into rotation about a central vertical axis, and always clockwise, when their separation is about an

inch or so. There is also some little tipping as the dog approaches and a slight translation of the ball, but if the ball moves away and the dog follows rotation continues. The effects are clearly the result of magnetic forces and since rotation is the principal motion a torque must exist to produce it. More than this, it appears that a couple exists.

A trivial study with iron filings and compass needle shows both ball and dog to have magnets imbedded in them. An X-ray view of each reveals the following: The magnet in the ball is a disk somewhat smaller than a dime (15 mm diameter) and 8 mm thick, and it lies on a face horizontally. The magnet in the front legs of the dog stands erect, that is, with flat faces vertical. The magnets are the same size. How, now, must these magnets be polarized so that the observed effects ensue?

An analytical study of disk magnets polarized facially or at diametral ends does not provide the answer. This was explored experimentally by embedding a magnet in half of a ping-pong ball. If however, the magnets are polarized on opposite sides of a diagonal the effects can be accounted for. For final evidence the magnets in the ball and dog were exposed and discovered to be so polarized. It is more than an elementary exercise to show what field orientation produces the observed motions.

Dancing Dots—An Electrostatic Toy

This toy is a thin-walled hollow plastic (acetate) sphere about 6″ in diameter. It has a heavy cardboard hoop (rim) about its equator which permits holding it between thumb and finger. Within it are some 50 various-colored pith balls about $\frac{1}{4}$″ in diameter.

When the system is electrostatically neutral, which is a very difficult situation to attain, all the pith balls reside in the bottom of the sphere, which is in keeping with energy considerations. But a peculiar aspect of this configuration is that they lie side by side in a huddle, ever so little apart, but never on top of each other. They are all in contact with the wall of the sphere, one deep. If gentle juggling does put some atop others the lower ones instantly separate and make elbow room for the upper ones. And it is not their weight which pushes the lower ones aside, which follows from an examination of the forces between spheres piled atop each other. The action is clearly electrostatic.

If the sphere is held by the equatorial rim and shaken gently a dispersal of the pith balls ensues; if shaken vigorously a violent separation takes place. These effects are enhanced by stroking or slapping the sphere with a piece of fur. If this charging operation (with the fur) is confined to the bottom of the sphere where the pith balls are congregated they stay there during the stroking but flee to all parts

when the fur is removed. If, now, the hand or fur is touched to the sphere at any point the pith balls congregate there but flee again when the ground is broken. The attraction is greater when contact is made with the fur. When in a dispersed array approach of a negatively-charged rubber rod forces greater dispersion while a positively-

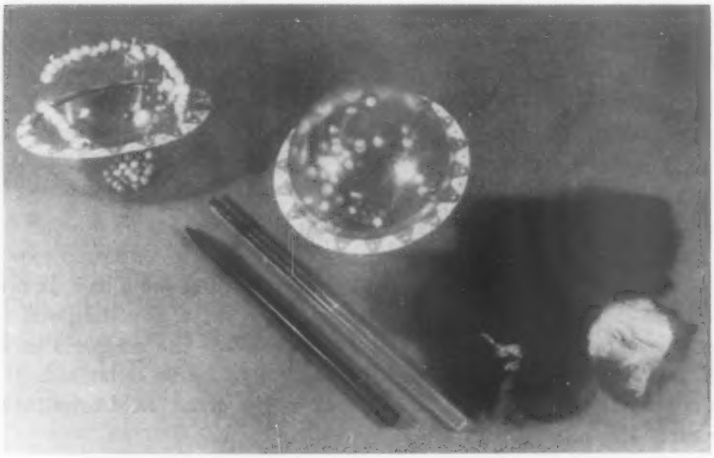

FIG. 8a. Dancing Dots.

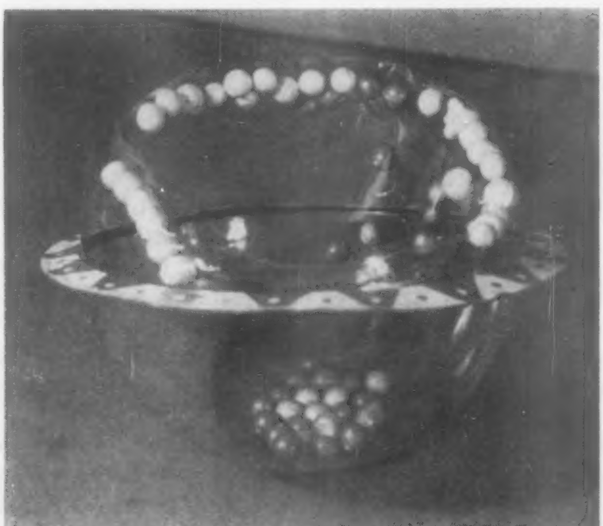

FIG. 8b. Dancing Dots (Deformed Sphere).

charged glass rod brings them near. All of these events are understandable on the basis of charge by conduction and by induction.

The electrostatic response of sphere and pith balls is astonishingly high. The plastic is an excellent dielectric and retains a charge for ever so long—in fact months.

A particularly strange behavior is demonstrated by a deformed sphere. Quite by accident part of one hemisphere was crushed in and instantly most of the pith balls rushed to this sharp-edged deformation. The mechanical strains obviously led to substantial polarization of the dielectric. And this deformed sphere now displayed another unusual behavior. When its smooth hemisphere is rubbed with the fur the balls flee during the rubbing but gather again at the spot rubbed when the fur is removed. This is just the opposite to what happens with an undeformed smooth sphere. Also, in this deformed sphere the pith balls lie several deep at the bottom, even when the entire system is heavily charged. This again is unlike the behavior of the undeformed smooth sphere.

Finally, the behavior of the undeformed sphere and its pith balls follows logical analysis. The case of the deformed sphere is somewhat enigmatic.

Magic Mirror Movies—An Optical Toy

Fig. 9. Magic Mirror Movies.

This toy consists of a phonograph record (78 rpm) and a "magic mirror." The record has painted on it in slightly off-concentric circular bands a sequence of pictures in successive stages of motion. To

illustrate: a frog is shown jumping from one lily pad to another. Successive drawings show him in a different phase of his motion. As is obvious, if this series of "frames" is passed before the eyes the impression of real motion ensues. There are on the record three such bands with sequences of motion. The outermost band has 16 pictures; the next inner one 15; the innermost 17.

The "magic mirror" is a 16-sided mirror each side $\frac{1}{2}''$ wide and $2''$ tall (long). These mirrors stand as the lateral faces of a conical frustum with lower base $2''$ in diameter and upper base $3''$ in diameter. Accordingly, the mirrors flare outward and upward from the center of the record. This mirror is mounted on the spindle of the player, atop the record. When, now, the record rotates, the figures on the record take on animation and are seen by reflection from the many-sided mirror. The music is synchronized with the motion of the figures.

A very intriguing physical aspect of this device is the following: Since the bands of figures are slightly spiralled, reflections from the mirors come at varying *vertical* positions on the mirrors which imparts a vertical motion to the animation. Further, since the number of figures per band is different and the linear velocities different a stroboscopic effect arises whereupon the middle ring shows retrograde motion. This means that the painted figures are headed backwards and their animated motion is backwards. On speeds of 33 or 45 rpm the music is unpleasantly slow and the animation sluggish.

This is an enchanting toy, and not alone for children.

PREDICTIONS OF SPACE EXPERTS RESEMBLE SCIENCE FICTION

A report just issued by the House Select Committee on Aeronautics and Space Exploration contains these predictions:

1. Man will orbit the earth before the end of the year.
2. He will land on the moon by 1965, and on Mars and Venus by 1968.
3. He may travel almost 670,000,000 miles an hour within 40 years, approaching the speed of light.
4. Within a decade, letters may be sent by rocket from New York to Paris and be answered in a matter of hours.
5. There may be world-wide TV also within a decade.
6. The day may come when worn-out human parts will be replaceable with miniature parts produced by the missile industry.

The report, entitled "The Next Ten Years in Spcae, 1959–1969," contains frank commentary from more than 50 space experts from several nations on what can be expected in future space developments.

NICKEL CONTROLS LEAF RUST

Inorganic nickel is coming to the aid of the wheat farmer. Field experiments indicate nickel salts, particularly chloride and nitrate, can control leaf rust of wheat, Applications of the nickel compounds eradicated wheat leaf rust and caused increases in yield varying from eight % to 21%, a scientific paper distributed by the U.S. Department of Agriculture states.

The Preparation of Pale Greenish-White Ferrous Hydroxide

Harold J. Abrahams and Stephen M. Poppel[1]
Public High Schools of Philadelphia, Pennsylvania

The color of ferrous hydroxide, obtained by precipitation resulting from mixing solutions of ferrous ions and hydroxide ions is variously describable as ranging from blue-black or green-black to light green.

One prescribed method[2] for the preparation of a lightly-colored product is based upon numerous studies[3] and is rather involved and troublesome.

The method which we give below is easily carried out and makes it at once easily possible for a person who has never seen the unoxidized product to observe its true color without going to great lengths to obtain it.

Preparation of Pale Greenish-White Ferrous Hydroxide

1. Bring 50 cc. of distilled water to the boiling point and continue to boil for one minute.
2. Into each of two six-inch test tubes, place between 5 and 10 cc. of the freshly-boiled, cooled distilled water, prepared in step 1.
3. Into one of these test-tubes place one gram of pure ferrous chloride crystals, and either two small iron nails or a strip of clean iron. Immediately add enough mineral oil to make a layer about $\frac{1}{4}$ inch thick. Now agitate gently in order to dissolve the crystals, without churning air into the water.
4. Into the other test-tube place 1 gram of pure sodium hydroxide. (CAUTION: do not use ammonium hydroxide.) Immediately add enough mineral oil to make a layer about $\frac{1}{4}$ inch thick. Now agitate gently as in step 3.
5. Immerse both test-tubes in a mixture of ice and ammonium chloride contained in a beaker or basin.
6. When the temperature has fallen to about 2°C., pour the sodium hydroxide solution into the ferrous hydroxide solution.

The product thus produced is of a pale greenish-white color which does not darken perceptibly on standing unstoppered (except for the sealing effect of the mineral oil) for a period of at least 10 months.

If the preparation of ferrous hydroxide is allowed to take place by merely mixing solutions containing ferrous and hydroxide ions, without exclusion of air, the product is so very nearly black, that carrying out two precipitations, one by the new method proposed herein,

[1] Second year student.

[2] Ludwig Vanino, "Präparativen Chemie," (Stuttgart, 1925), Volume 1, pp. 628–629.

[3] a. *Compt. rend.*, 84: 443 (1887); b. *Ann.*, 95: 116 (1855); 63: 101 (1840); c. *J. Prakt. Chem.*, 76: 239 (1859); d. *S. A. Ber.*, 44: 1608 (1911).

and one by merely mixing solutions of both ions offers a striking contrast and an opportunity to study the relative value of the methods.

The method also offers an excellent example of a) the air as an oxidant and one simple way in which its action may be prevented and b) the easy transition from the lower to the higher valence states of iron.

Other References on Ferrous Hydroxide

Harry B. Weiser "The Hydrous Oxides." (New York, 1926), pp. 74–75; *J. Phys. Chem.* 19: 232 (1916); *Liebig's Ann. Chem.* 22: 56 (1838); 36: 101 (1840); *Compt. rend.* 69: 179 (1869); 109: 266 (1889); *J. Chem. Soc. Japan* 43: 397 (1922); *J. Am. Chem. Soc.* 47: 70 (1925); *J. Chem. Soc.* 119: 932 (1921); *Ber.* 71: 992 (1938); *Z. anorg. Chem.* 174: 145 (1928) and 251: 414 (1943); *Naturwis.* 31: 326 (1943).

THE UNCERTAINTY ATTITUDE: A TEACHING OBJECTIVE

Robert C. McLean, Jr.

Physicists, having established the "uncertainty principle," can be credited, or blamed, as the source of this suggestion for a new phrase in pedaguese: "The uncertainty attitude." This is not a new concept. The set of words, however, is presented as a general name for several objectives of science and mathematics education which have hitherto not been recognized as constituting a group.

The simplest example of the use of the uncertainty attitude arises in the solving of arithmetic exercises: "Check your work!" This admonition, in terms of the suggested principle, would be considered an expression of the necessity to indoctrinate the student with an attitude of uncertainty about the correctness of his calculations.

A second example of an attitude encompassed by this phrase is the admonition: "Accept nothing as true without proof!" Some teachers enthrone this attitude under the title "scientific attitude." The most common use of it actually is in the geometry class, where it is generally not dignified with any title whatsoever. The corollary of the scientific attitude, that one must accept some things as true without proof, also falls under the classification of the uncertainty attitude. The prime example of this is the development of non-Euclidean geometries. Thus, even that which one treats as "true," may give way to further "truthes."

A third example, which follows from the second, is the fact that scientific knowledge outraces the textbooks. Whereas the axioms and postulates of Euclidean geometry are presented as a list of assumptions, the laws of the various sciences are often taught in class as if they were whole and complete and that future discoveries will leave them unchanged. This approach is contrary to that of the uncertainty attitude. The teacher who is sincerely trying to achieve appreciation of scientific development must prepare his students for the future discoveries of scientific research which may revolutionize the principles and laws which the student is so confidently studying

Although politicians and generals may not wish the people under their government to take an attitude of uncertainty toward their superiors or even toward each other. (A soldier *must* have self-confidence!) In the science and mathematics classroom, it would seem to be a denial of the lessons of the history of scientific achievement to foster any attitude other than that of uncertainty—uncertainty toward the pronouncements of the teacher and the textbook, uncertainty toward the present knowledge of science, even uncertainty toward one's own abilities. Such uncertainty should be expected to lead toward more careful work, more intensive study, and a dissatisfaction with incompleteness.

The Indianapolis Science Story

(Now Two Years Old—The Year 1—A.S.*)

Newton G. Sprague

Indianapolis Public Schools, Indianapolis, Indiana

Two years ago at the convention in Chicago Mr. E. B. Newill, General Manager of the Allison Division of General Motors spoke to you about a local action committee which had been formed in Indianapolis. Your chairman asked me to report the progress of the committee over the past two year period.

The original committee was formed under the joint sponsorship of the Indianapolis Board of School Commissioners and the Indianapolis Chamber of Commerce.

After a year of operation, it was expanded to include ten school science educators and administrators from Indianapolis and Marion County schools and seven representatives of local industry and business. I have been privileged to serve as the committee's secretary since its beginning.

From the time of its conception the members of the committee have kept in mind the basic questions.

"How can more young people be stimulated (or required) to take basic courses in mathematics and science to prepare them for college training in technical and scientific fields? What devices or methods might be put to use?"

"Are there enough able teachers in the field of mathematics?"

a. Is there need for stimulating more bright young people now in high school to make teaching in these fields their career?

b. Is there need for refresher courses for present teachers in these fields?

c. Is there need for more laboratory equipment in the schools?

d. Are the curricula in these fields adequate to our needs?

The committee has always tried to accomplish some immediate objectives while working on the long range ones. Therefore, the committee proposed that the committee on science and mathematics education make formal requests, through the superintendents of the various public school systems of Marion County, that sufficient funds be budgeted for the year 1956–1957 to supply equipment for an adequate science program in each junior high school, and that a suggested list of equipment be submitted.

As a result of this recommendation, the Indianapolis Board of School Commissioners appropriated approximately sixty thousand dollars for science equipment and supplies during the 1956–1957

* A paper presented at the *General Science Section, 1958 CASMT Convention*, Indianapolis, Indiana, Nov. 28–29, 1958.

school year. Money is one thing and converting it into usable supplies is another.

In the past, several teacher committees had developed supply lists for the various units given in the junior high school science course of study. However, since each school was limited, at that time, to an expenditure of $25.00 per semester, the lists were not very extensive. That was the starting point.

Other sources of information for teacher equipment and supply needs were Curriculum Bulletin No. 20, *Science—A Guide For Teachers—Junior High School*, and Curriculum Bulletin No. 20—Supplement. These are two publications which were developed during a period of time between 1953–1955 by the junior high school science teachers of Indianapolis. Many of the activities given in the bulletins required specific equipment and materials. These were also added to the list.

Representatives from several schools had requested permission to save their "$25.00 per semester" until they could buy a microscope. If you can imagine teaching thirty-five students using one microscope, you will recognize the problems and the need for a different solution to this request.

Another large item which many teachers had asked for was a portable laboratory table. A survey of twenty-five junior high school science teachers gave a list of features that they would like built into a laboratory table. Three sets of drawings were made and within three months the first of seventy-two portable laboratory tables rolled out of our school shops. From our pilot model Allison Division personnel made more self-explanatory drawings.

The tables are very versatile. Some of you observed their use at the Instruction Center yesterday. They are mounted on excellent rollers, have large storage space for experiments which are prepared in advance of class time, are of sturdy construction, have natural wood finish and have three levels from which demonstrations can be conducted.

When the upper level or bars are not necessary they can be stored in a special compartment along the rear of the table. It has two shelves $40\frac{1}{4}$ inches deep to facilitate the storage of glass tubing, meter sticks, and other long objects. The table top and extension top are are made of $\frac{3}{4}''$ plywood and a layer of $\frac{1}{4}''$ Transite, an asbestos-cement pressed board. The working surfaces have been given additional coats of varnish. We hope that the use of these excellent facilities will bring this young student teacher back to our system as a qualified junior high school science teacher.

The shelf position makes an ideal place for those individual student experiments which are so valuable for the better student.

If a larger surface is necessary, the shelf may be stored on the back, ends dropped, and a working area of $31\frac{1}{2}'' \times 41\frac{3}{4}''$ obtained. One piece of equipment which has helped to make the table more mobile is the use of a liquid pressure type burner as a source of heat.

One of the original questions was "Is there need for refresher courses for present teachers in the fields of mathematics and science?"

The famous saying by Sophocles, 445 B.C., "One must learn by doing the thing; for though you think you know it . . . you have no certainty until you try . . . ," most certainly applies to science teaching Therefore, a professional training program was activated to familiarize the junior high teachers with their new equipment, to develop new experiments and demonstrations, and to give additional knowledge in both the biological and physical sciences.

One type of meeting was held after school 3:45 P.M.–4:45 P.M., in various parts of the city. A second type of meeting was held out-of-doors at Camp Riley as a part of the school camping program.

A microprojector for each junior high school was a partial solution to the requests for microscopes. It is felt that many features of the microscope can be explained more satisfactorily to a junior high school group by means of a microprojector. Physical science experiments have been developed for use with the microprojector (i.e. Crystal growth and structure, polarized light and stress analysis in plastics, water of crystallization, electroplating, etc.).

Another type of professional growth program was the offering of a one week summer workshop, Demonstrations in Science. There were a total of 90 participants in three such workshops and some of the units explored were in the following areas:

Metric system	Rolling Armature
Laboratory Safety	Microprojection
Purification of Water	Simple Machines
Flame Tests	Electricity

In this slide a junior high school teacher is explaining the principles involved in a "block-and-tackle." You will recognize that many of these subjects once were taught and considered the property of high school science courses.

The second proposal of the committee was "that a pilot program sponsored by local industries and Marion County schools and coordinated by the committee, be carried out in the fall, to provide tours for junior and senior high school students to local industries in order to stimulate more interest in basic courses in mathematics and science."

This project was carried out on November 8, 1956. Forty-two select 9th grade algebra students learned many valuable facts at Allison Division of General Motors.

A similar group selected from the 8th grade science classes of the county made a stimulating tour of the Eli Lilly Pharmaceutical Company. There was a large quantity of notes made and many scientific questions asked. Perhaps the student anticipated that he would be asked to evaluate the tour.

The following comment is typical of student reaction to the pilot study. "I have been thinking of entering into a field of science for some time, but I have not yet decided what field I should enter. The trip to the Eli Lilly Company gave me many new ideas and has helped me to better understand and decide which field of science to enter."

An assistant principal wrote, "I personally feel the science tour was of great benefit to Dick. It provided him with more confidence, both in the classroom and school generally. The tour . . . has resulted in more attention being focused on science from the other pupils. Many pupils have asked about the opportunities of taking a similar tour, and seem to feel that going as an individual is more of an honor than going in a group."

The pilot study was for boys only. It was considered such a success that on March 12, 1958, it was repeated having as participants 196 students and 6 industries. Approximately one third of the students were girls.

The six companies participating in the program this year were:

1. Eli Lilly and Company
2. Allison Division of General Motors Corporation
3. Speedway Laboratories Linde Company
4. Chrysler Corporation
5. Western Electric Company, Inc.
6. Link Belt Company

Three of the companies had representation in the Industry-Schools Committee; three did not.

A new method of evaluation and reporting to industry was added to the student and teacher reaction letters. A tape recording was made of student reports to classmates, science clubs and auditorium groups. Three or four reports from different students but related to the same industry were spliced together and presented to the respective industry for their listening. It was definitely found that by this method that a student recalled and transferred more information than he would if he was asked to write a report on the tour. Our students, like most adults were more spontaneous with their verbal reactions than they were with their written reactions.

Perhaps it will be of interest to know that the student participants were selected from all types of schools; city, county, metropolitan township, State School for the Deaf, parochial, and private.

The Committee is still evaluating the larger tour program and does not plan to repeat it before the spring semester of 1959.

Proposal 3 of the committee—"that Business-Education Day plans be modified this fall in such a way that science and mathematics teachers can be grouped and invited to plants where specially designated programs can be prepared for them."

This proposal has been followed two times. Science and mathematics teacher reactions were, as a whole, in favor of the new procedure. One teacher wrote:

"The trip was excellent since a good leader was in charge of that particular group. We were most fortunate in having the best I have heard. Reasons why I thought it was good:

a. Director of research gave main address.
b. Tried to bring us a bit up-to-date on wonder drugs and polio vaccine.
c. Concentrated on research in plant.
d. Showed us one phase of production to fill out pictures.

Some teachers suggested "more demonstrations set up in laboratories. Small groups watching calculators at work for a longer period of time."

"We could have seen the plastic molding and heating equipment; also the laboratories where plastic was tested."

Some constructive criticisms were:

Group all the senior high school and mathematics and science teachers together.

Why separate biology, etc., from the physical science and mathematics teachers?

Have the junior high school science and mathematics in a second group.

Would desire to hear a "Bang-up" good address on a specific science problem area.

Suggest industry do "Parent Education" in regard to the importance of mathematics and science.

Would appreciate hearing industry speak out in favor of high scholastic standards.

Proposal 4.—"That expenses of teachers attending regional or national conferences of associations such as the Central Association of Science and Mathematics Teachers, be defrayed either by the Board of School Commissioners or through voluntary private funds."

Twenty-five teachers attended such conferences in the spring of 1957 as a part of a pilot program supported by voluntary private funds. Grants were made to applicants from all school systems within the county.

After evaluating the pilot study the committee recommended proposal 9 which is a modified form of proposal 4.

The Indianapolis Board budgeted for 1957–1958 $3,600 to send mathematics, biology and physical science teachers from the eight high schools to such conferences. As imilar amount has been budgeted for the present school year. Similar funds were budgeted in the other public school systems in the county.

While all of this activity was going on in the junior high level, the high school principals, with their department heads in science had been studying and discussing the high school science program. Recognizing the fact that many potential science students may have been lost in the past at the ninth grade due to the lack of a science course for them to take, certain suggestions to change this were made by a committee composed of the assistant superintendent in charge of curriculum and supervision, the consultant in science and mathematics, and two high school principals.

On February 26, 1957, the general superintendent, Dr. H. L. Shibler, presented and the Indianapolis Board of School Commissioners approved the following resolution:

". . . Beginning in September 1957 . . . every Indianapolis high school shall offer a science course to every 9B pupil, who, in the judgment of the principal has the ability and the maturity to profit from the course."

". . . No later than September 1958 a new course in physical science be developed for all 9B pupils wishing to elect it, within the necessary restrictions pertaining to class size." The committee for the development of this phase met during the 1957–1958 school year and produced *Physical Science for Ninth Grade*, a tentative Guide for Teachers Bulletin No. 44. The teachers of the course have been asked to record suggestions for either changes or additions to the Guide, as they use it during this school year and to submit them for a revision at the end of the 1958–1959 school year. It is *not* available for distribution to other school systems during this trial period.

In Spring 1958 there were 1,602 students of the Indianapolis Public Schools enrolled in the Physical Science course as compared to the 484 of the previous year.

The second part of the resolution was approved as follows:

". . . For graduation from Indianapolis high schools, beginning no later than with the graduating class of 1961, there be required a minimum of one year of physical science and one year of biological science, one of which must meet the state requirement of one unit in a laboratory science." This ruling necessitated the construction of more science laboratories and the hiring of more *good* qualified science teachers.

May I refer now to the increase in our high school science enrollments. In the fall semester 1955, the science enrollment was 4,479 or

27.4% of the total high school enrollment of 16, 362. At a similar date in 1956 the science enrollment was 5,575 or 34.7% of the total high school enrollment of 16,075. The fall of 1957 science enrollment was 6,824 or 41.7% of the total high school enrollment of 16,346. This fall science enrollment was 7,552 or 45.6% of the total high school enrollment of 16,528. This shows a gain of 7% for each of the two years. There is a gain of 3.9% this year. Part of this is due to the School Board ruling of February 26, 1957. However, we are certain that a part is also due to the new emphasis placed on science throughout the country and in our junior high schools during the past school year.

One of the early proposals of the committee developed from the need to broaden and refreshen the training of senior high school science and mathematics teachers.

Proposal 5 was stated as follows: "That plans should be developed with universities for local broad, refresher type classes for junior and senior high school science and mathematics teachers to be subsidized on a one year try-out basis by local industries."

A series of 15 "Seminars in the Sciences" was planned with the faculty of Purdue University. One a week was given in the evening at one of our high schools between January and May 1957. The attendance ranged between 56 and 162.

Dr. Tendham of the Purdue Physics Department conducted the first meeting on the topic "Radioisotopes." Topics were presented in both the physical sciences and biological sciences. Teacher reaction indicated that the series was too long and that the effort to appeal to an audience with such varied interests and backgrounds was an error.

With the science program gaining momentum, attention has been turned to another important area, Modern Mathematics and Its Implications for the Secondary Curriculum. During the fall 1957 Dr. Sawyer and Dr. Bing were brought to Indianapolis as inspirational speakers in this area. A second part of the movement was a series of five lectures January through May. The meetings were held after school, 3:45 P.M.–5:00 P.M. At the time of the making of this slide seventy-five teachers had indicated a willingness to pay an enrollment fee of $7.50 for the series. This was the final enrollment. Dr. Snapper was the lecturer. This interest I am sure is due, in part, to "Seminars in Sciences" which were paid for by industry in the spring of 1956.

An interesting experimental program was conducted at Arsenal Technical High School to appraise the possibilities for conserving more of the lesser-talented in mathematics for technical level jobs. The experiment was to determine the motivational value of the Ma-

chine Calculator in teaching mathematics. Most significant in the opinion of one instructor was the strong motivational device which the machine afforded. It was concluded that the proper use of calculating machines for the slow learner in general mathematics results in greater ability in both computation and in reasoning than the learning that is done without the use of these machines.

As we look to the future, it is planned that greater emphasis will be placed on student participation in national project contests. At the present time, a student in one high school, supported by consultant service from personnel of three local industries is conducting an experiment in "beta decay."

. . . That greater use will be made of experimental science programs on television and radio. One of our programs was report in SCHOOL SCIENCE AND MATHEMATICS last spring.

. . . That cooperation will continue and increase between the junior high school science teachers and the junior high industrial arts teachers who have helped supplement our science program during the past years with units on electrical symbols, wiring diagrams, radio theory, wire splicing, etc.

A proposal of the committee which has had far reaching results was Proposal 8, which is stated as follows: "that a request be made to a local foundation, for money to assist science and mathematics teachers in continuing their study in these subjects."

As outcomes—On September 13, 1957, the Indianapolis Foundation granted $10,000 to the Industry-Schools Committee for use during calendar year 1958. The grant is renewable for two additional years. During the period November, 1957–August, 1958, $10,000 was expended in the form of grants to teachers for study in the areas of mathematics and science. So far this fall approximately $1,600 has been granted for academic year study in those areas. These grants were made to teachers in junior and senior high schools of the county. It was not necessary that the applicant be teaching in those areas at the time of the grant. One instrumental music teacher took more science under this program and is now teaching junior high science. She is doing an excellent job. Several intermediate teachers have been up-graded by this method.

We feel in Indianapolis that our program will continue to expand. We hope that it will help correct the shortage in science and technical personnel which our country faces today.

If we can be of any assistance in the development of a similar program in your "home town" feel free to call on our resources.

Identifying Potential Scientists: A Multivariate Approach

William W. Cooley
Harvard University, Cambridge, Mass.

One of the more frequent pleas which is being made to educators today is to do something for the future scientist. "Let us identify and encourage the potential scientists" is often heard, yet is never defined. The statement conveys the impression that we know how to identify them. However, this is *not* the case.

Empirical evidence indicates that it is possible to identify certain characteristics for which scientists *as a group* differ from the general population more than could be expected to occur by chance. Such results are interesting and lead to elaborate "theory-spinning" about the "typical" scientist, but the information is not functional for the practicing guidance man, school administrator, or science teacher, who must deal with individuals, not group tendencies.

This paper is an attempt to re-define the problem of identifying potential scientists so that it can be dealt with more efficiently. Multvariate statistical methods useful in attacking the problem are suggested and illustrated with an example using existing data. This approach could eventually lead to an operational definition of the potential scientist.

A Test Space Model

It is safe to begin by assuming that not every high school boy could or would become a scientist.* "Could" in the sense of being able to develop the necessary abilities, and "would" in the sense of having personality characteristics which make it possible to maintain a sustained interest in aspects of scientific work such as precision, things, and a search for order. This suggests the question: "How can we best define the range in the combinations of abilities and personalities of the individuals who eventually go into some field of science?" If this information were known for various age levels, it would be possible to help the student who asks, "Do people like me go into science?" Measures of his ability and personality could be compared with the defined Potential Scientist Pool† corresponding to his stage of development. Of course, we cannot expect to narrow down this

* In this paper, "scientist" is used in the general sense of anyone occuping a vocational position which necessitated at least a four year major in one of the natural sciences. For guidance purposes, however, this scientist group must be broken down into more specific areas of science and types of work within science (teaching, research, administration, etc.).

† Students who "look like" former students who have found a satisfying career in science are considered to be in the *PSP*. Further discussion of the *PSP* can be found in (3).

Potential Scientist Pool to include only the 0.5% of the population who eventually go into science, but through use of modern statistical models, prediction for an individual can be improved over lists of group tendencies now available.

The most reasonable procedure for comparing people in terms of their measureable attributes is by use of a test space model. In this approach, individuals are represented by a point in a space whose reference axes are the variables for which scores are available on each individual. The two-test case can be represented on a plane. Figure 1 illustrates this test-space procedure. The *o*'s and *x*'s representing, for example, scientists and non-scientists, are positioned in this two dimensional space according to their scores on variables *A* and *B*. It can readily be seen how a third axis (variable *C*) could be added at right angles to *A* and *B*. The *C* scores might be such that the *o*'s and *x*'s are separated still more.

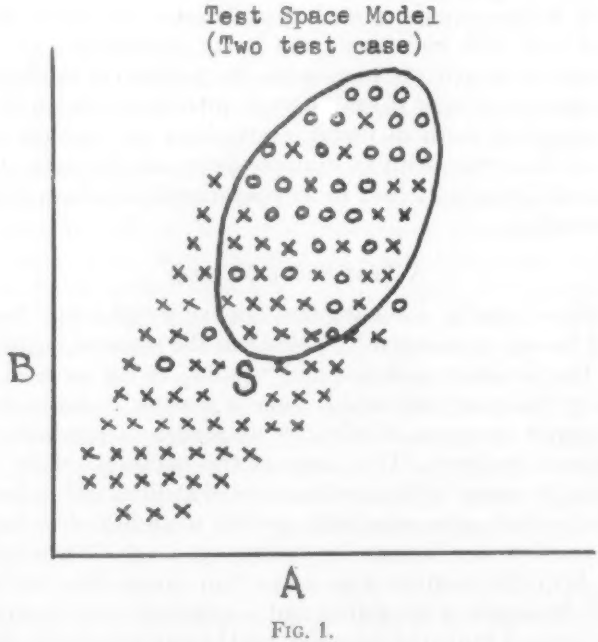

FIG. 1.

Extending the procedure to a space of four or more dimensions is difficult to visualize but it is possible to represent and deal with such distributions by use of matrix algebra. It is also possible to reduce the number of dimensions (axes) by using certain types of multivariate analysis, such as discriminant analysis.

As can be seen in the two-space example, people with the same or similar score combinations occupy the same area in the test space. To describe the density (frequency) of certain combinations at various positions in the test space, Tiedeman (10) has suggested the use of centours (*cen*tile con*tours*) which define the proportion of a given group which lies outside a given area of the test space. In the two-space for instance, the centour would be an ellipse. The ellipse indicated in Figure 1 would be the tenth centour (10% of the *o*'s lying outside the ellipse) for the scientist group (*o*'s). The higher the centour value, the closer to the center of the group a given individual would lie.

For example, let us suppose the variables A, B, C, etc. were obtained on several students during high school, and the criterion (o or x) was determined by waiting for them to move out of school or college and into a satisfying career. Then, later on, when high school student "*S*" wants to know, "Do I look like an *o*?" by measuring A, B, C etc. for him, and locating his position in the test space, we will have some information to give him. If several occupational groups are defined within the same test space, centour scores can indicate which group an individual most nearly resembles.

Those individuals who lie within that centour which encloses almost all those who go into science might be called the Potential Scientist Pool. That is to say, in so far as we have measured those attributes necessary for continued interest and success in science, those people lying within this centour look like others before them who have found a stisfying career in science.

Let us now turn from ivory-tower fantasy to the cold facts of real live people and see how this multivariate model works "under fire" of actual data.

Analysis of Longitudinal Data*

The data used were collected at the Forest Hills High School, New York and were made available by Dr. Paul Brandwein.† The subjects used in the multivariate analyses all participated in the pre-scientist curriculum at Forest Hills, graduated between the years 1947–1954, and had Henmon-Nelson IQ's above 140. Since careers had been followed after high school gradaution, the problem was to distinguish among the various post-high school career directions from a knowledge of data collected during high school.

The classification of the subjects into uniform criterion groups was difficult because the sample included graduates over a seven year

* The remainder of this paper is essentially a summary of Chapter III of the author's recently accepted doctoral dissertation (4).

† Information on the science program at Forest Hills can be found in (1)

period. Hence they are now at different stages in their career development. The author has pointed out elsewhere that a more reasonable approach in vocational prediction problems is to work toward prediction from stage to stage, rather than expect to accomplish long range prediction (3). Therefore it was decided to use the career direction as of the sophomore year in college, thus solving the problem of a uniform criterion. Table I gives a breakdown of the subjects according to career direction at the second year of college.

TABLE I
CRITERION GROUPS FOR THE DISCRIMINANT ANALYSIS

Group	Number	Sex	
		M	F
1. Physical sciences	31	19	12
2. H. S. science teachers	23	5	18
3. Medicine and dentistry	27	18	9
4. Engineers	31	23	8
5. Behavioral science	25	6	19
6. Law and humanities	37	16	21
7. Business	38	22	16
8. Biology	16	7	9
9. Mathematics	23	10	13
Total	251	126	125

THE VARIABLES

The variables included in this investigation are listed below in the order in which they will appear throughout the discussion.

1. Sex (1 = Male; 2 = Female)
2. High school scholastic average (arithmetic mean, 0 to 100)
3. Religion (1 = Catholic; 2 = Jewish; 3 = Protestant)
4. The Henmon-Nelson Test of Mental Ability: Grades 7–12. (V. A. C. Henmon and M. J. Nelson, Boston: Houghton Mifflin Co., 1930–1950.).

Differential Aptitude Tests: Grades 8–12. (G. K. Bennett, H. G. Seashore, and A. G. Wesman, New York: Psychological Corporation, 1947–1950)

5. Numerical Ability
6. Abstract Reasoning

Primary Mental Abilities, Form A; Ages 11–17. (L. L. Thurstone and T. G. Thurstone, Chicago: Science Research Associates, Inc. 1947–50)

7. Verbal meaning
8. Reasoning
9. Number
10. Word fluency

Brandwein Inventory of Predisposing Factors (BIPF):* In an effort to obtain a measure of certain personality characteristics which are believed to be related to choice of and success in a scientific career, Brandwein divided ten rating scales based on operations thought to underlie persistence and questing. Nine

* Further information on this inventory can be found in (1).

of the ten scales were used in the analysis. The tenth, scholastic average, was dropped since the original averages were available for analysis. The six point scales were based on the following observations:

11. Attendance: Number of days absent from school due to minor illness, colds, etc.
12. Interest: Number of hours per week spent in science hobby work outside school
13. Width of Interest: Number of projects chosen from a list of twenty-five suggestions
14. Perserverance: Number of changes in project topic after commitment to one chosen because of interest
15. Free Periods: Number of free periods spent in laboratory in advanced science
16. Reading habits: Nature and extent of leisure time reading (based on interview)
17. Personal History: Comparison with previous students whose continued interest in science is known
18. Ambition or drive: Same as 17
19. Questing: Tendency to ask question of an original nature

The Multiple-Group Discriminant Function

An appropriate statistical procedure for analyzing these data is multiple discriminant analysis. This procedure makes it possible to reduce the nineteen dimensional test space resulting from the variables listed above by forming linear combinations of these nineteen variables. These linear combinations, called discriminant functions, preserve most of the information about group differences which these nineteen scores contain.

The most frequent use of discriminant analysis is as a predictive tool, the job for which it was devised by Fisher (5) in 1936 (for the two-group case) and later generalized by Rao (7), Tukey (12), and Bryan (2) (independently) for the multiple-group case. The task is to assign individuals to one of two or more groups on the basis of two or more independent measurements of each individual. The general procedure is to measure the same predictor variables on a large sample for which group membership is known and then derive discriminant functions which weight these measures so that their weighted sum minimizes the overlap between groups. New individuals can then be classified by determining the group which they most nearly resemble.

As a predictive device in education, the discriminant function's widest use has been in the area of counseling. At present, however, this use is limited to large institutions who can afford the high cost of the necessary computations and who have personnel informed of its possible application.

Using the results of discriminant analysis in counseling high school students with respect to science would probably have to depend upon a large scale study of a representative group of students from several

schools from which a simplified scheme for interpretation by school personnel could be developed.

The second application of discriminant analysis is as part of a test of the significance of group differences. Although this aspect of its application is in the early stages of development, a few procedures are available. In this empirical study the question of whether or not the nine college major groups can be considered as random samples from a common population was asked. Once over-all group differences have been established for the nineteen variables in combination it will be more reasonable to examine and discuss differences on indivdual variables, thus reducing the danger of capitalizing on chance differences.

THE LATENT ROOTS

The mathematical derivation and interpretation of the discriminant equations are numerous (2, 7, 8, 9, 10, 11), so those details need not be gone into here. The resulting roots and their associated vectors are listed in Table II. The latent root defines the ratio of the among-groups to the within-groups sums of squares (similar to the F-ratio in analysis of variance). Thus the relative extent to which the associated function distinguishes between the nine groups can be seen by the size of the roots. In this particular problem, about three-fourths of the information concerning group separation is described by the three linear functions associated with the first three roots,* and since the fourth and fifth roots were more inaccurate, only the first three roots and their associated vectors are used in describing the discriminant space.

THE LATENT VECTORS

The nineteen elements of each of the three vectors are the weights used for combining the corresponding variables. When each of the three are multiplied by a vector of deviation scores (from grand mean) the resulting scales represent the coordinates of the three axes in the discriminant space for the individual whose deviation scores are used.

The size of these weights does not indicate the relative discriminating power of the variables because their size is also a function of the variance of their corresponding variables. The elimination of this scale factor is carried out and discussed later (Table V).

SIGNIFICANCE OF THE GROUP DIFFERENCES

Testing the significance of the difference between many variates on several groups still lacks a satisfactory solution. Rao (8) presents a procedure for using Wilks' Lambda criterion in a variance ratio test,

* I.e., 73% of the total discriminating variance is accounted for by the first three functions.

TABLE II
THE LATENT ROOTS

No.	Root	Cumulative Proportion of Trace Accounted for
1	0.35516	.3466
2	0.20402	.5456
3	0.18388	.7251
4	0.096	.8197
5	0.078	.8965

Trace of $W^{-1}A = 1.02479$ [Total discriminating variance]

THE LATENT VECTORS

	Vector 1	Vector 2	Vector 3
1	1.000000	1.000000	1.000000
2	−.022597	.007269	−.011550
3	.291658	−.210909	.149842
4	−.173133	−.026819	.147981
5	.016939	.012220	−.058135
6	−.298111	−.031112	.124801
7	.131308	−.157313	−.016668
8	−.203184	.010329	.036891
9	.187640	.066330	.087586
10	−.228904	.125809	−.217413
11	−.033015	.324120	.256235
12	−.463982	−.241059	.344152
13	.545353	.123167	−.503899
14	.678585	.120814	.026794
15	−.002239	−.287290	.157936
16	−.175700	.280772	−.267419
17	−.180527	.199707	.119995
18	−.339004	−.263416	.307199
19	−.263650	−.179655	−.507815

but this test often results in accepting homogeneity when differences actually exist. The reason is that the Λ-criterion is a test of the over-all significance and significant roots may be obscured when several others in the solution are small. Some procedures have been developed for testing the separate roots but not for the parameters involved here (6).

However, before proceeding to the task of determining the practical significance of the group separations, at least an estimate of the statistical significance of the group differences can be obtained by using the procedure outlined in Rao.

The F-ratio found for this discriminant solution was 1.48 with degrees of freedom of 152 and 1825. The probability of obtaining an F as large as this or larger is less than .01 and the hypothesis that

these nine groups can be considered as random samples from a common population is rejected.

The importance of this test is that it tends to reject the hypothesis that vocational choice is a random process and it gives encouragement to the further pursuit of the problem of vocational prediction. The inclusion of other factors in addition to the ability tests and teacher rating scales used here might prove profitable.

Practical Significance of the Separations

Although establishing statistical significance between the groups is important, if information resulting from this sort of analysis is to be used for guidance or selection purposes there must also be practical separation of the groups. Two concepts are available which aid in describing the relative positions of the groups in the discriminant space and the degree of overlap between the groups.

The "centroid" describes, in a sense, the center of gravity of the group distributions, and the "centour" describes the densities of the group distributions, at various distances from the group centroids. These measures assume multivariate normal distributions of the discriminant scores and that assumption would have to be tested if the functions were to be used for guidance and selection purposes. This is generally the case if the original variates are normally distributed (10).

Group Centroids

In Table III are listed the group centroids. These were computed by finding the deviations of group means from the grand mean, and reducing this test space vector to a vector in the discriminant space. In vector notation the equation is $\bar{d}_{ig}=(X_g-X_T)v_i$, which results in the ith coordinate of the group g centroid in the discriminant space.

Figure 2 shows the location of the points using a simulated three-

Table III

Group Centroids

Group (g)	$\bar{d}_{1g}$	$\bar{d}_{2g}$	$\bar{d}_{3g}$
1	−2.680	.076	−.206
2	.654	−.0965	1.192
3	.168	−.140	.0696
4	.240	−.693	−.388
5	1.882	.569	−.473
6	− .351	.299	−.0476
7	.987	−.175	−.189
8	− .446	.313	.101
9	− .365	.066	.359

coordinate system. The third axis is placed at an angle of 60° to the first axis but is interpreted as being perpendicular to the plane of the paper, with the solid line protruding out toward the reader.

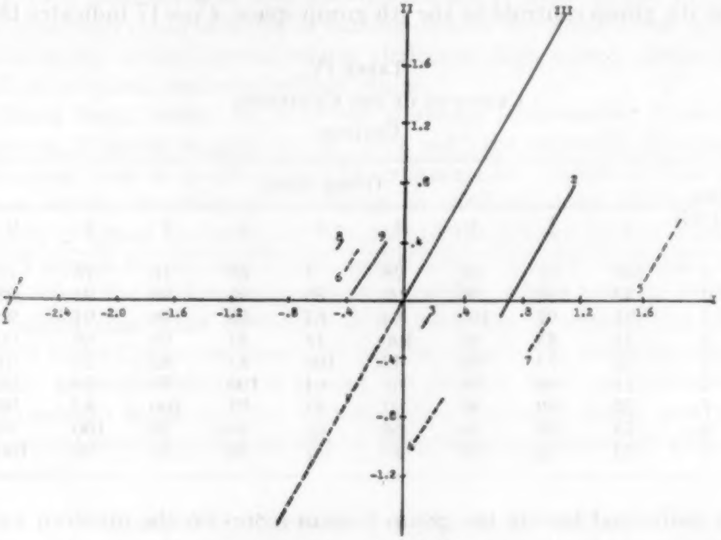

FIG. 2. The group centroids.

As this diagram shows, the group most distinctively separated is physical sciences. Having some separation on axes II and III are the centroids of the engineers and high school teachers. It is tempting to look at the functions and name them on some *a priori* basis. Thus, function I might be labeled "thing-oriented (+) vs. people-oriented (−)" with almost perfect "agreement." However, an examination of the variables which produced these separations makes such inferences untenable.

The next question which needs to be examined is the group distributions in this newly derived three-space. It is important to keep in mind that this new space is a result of reducing the original test space of nineteen dimensions by choosing three axes (for which the normalized vectors are the direction cosines) in such a way as to obtain the minimum overlap between the groups. In other words, the separation of group distributions, discussed in the next section, is the ***best*** that can be achieved by three linear combinations of the nineteen variables used in this analysis.

Centours of the Centroids

A convenient procedure for showing the degree of overlap between

the groups consists of computing the centour (described earlier) for the group A centroid in the group B space.*

Table IV below gives the centour equivalents for each of the nine centroids in each of the nine group spaces. The centour C_{ij} is for the ith group centroid in the jth group space. $C_{12}=17$ indicates that

TABLE IV
CENTOURS OF THE CENTROIDS
Centours

Centroid	Group Space								
	1	2	3	4	5	6	7	8	9
1	100	17	61	28	7	80	16	78	73
2	42	100	99	90	80	96	99	92	98
3	51	97	100	94	64	98	96	94	99
4	31	85	96	100	41	83	96	68	90
5	12	73	80	42	100	83	92	73	61
6	71	90	98	68	64	100	80	99+	99
7	27	99	98	92	83	92	100	83	98
8	73	89	96	66	61	99+	78	100	99
9	73	92	99	83	57	99	85	99	100

an individual having the group-1-mean-scores on the nineteen variables would be closer to the center of group two than would seventeen per cent of the members of group two. High values on the off-diagonals of the centour matrix indicates a high degree of overlap between the groups. Lack of perfect symmetry in the matrix is due to differences in dispersion for the corresponding group pairs.

Several groups with centroids around the origin of the discriminant space cannot be distinguished from each other. Groups for which there is almost complete overlap are 6 (law), 8 (biology) and 9 (mathematics); 9 (math.) and 3 (medicine); 2 (teaching) and 7 (business). Some of these "families" seem peculiar, but, as is pointed out more explicitly in the next section, group separations are based primarily on scholastic aptitude and achievement, manifest interest in science, and sex. Many of our "common sense" notions of group similarities which do not agree with the group families above are, perhaps, based on aspects of the personality not included in the original nineteen variates, or which are not applicable to this specific sample. It is also possible that many of our stereotypes are inaccurate.

Any discussion of the application of the information resulting from individual discriminant scores must be in terms of specific uses. As a

* This procedure was suggested to the author by P. J. Rulon.

guidance tool, discriminant scores could be helpful when the student wants more information about himself in relation to his fellow students. Although some groups cannot be distinguished by these three functions, students who seek information about those groups which are separated could be aided in making certain decisions. These decisions might involve special course choices in high school, choice of college, or plans regarding college major.

Using these results for selection purposes is somewhat limited, however. Current suggestions to "pick out" the potential scientists and place them in special science programs are not realistic in view of these results. Deciding to discourage or eliminate from the special science program students not like any of the science groups would affect almost no one since the three non-science groups overlapped at least one of the science groups. Even if possible, such a practice might be undesirable, since continued widespread use of centour cut-offs would make the groups more and more homogeneous and some variability is needed within the groups. At present, then, an individual discriminant score and the corresponding centours would best be limited to providing information for the guidance of these high ability students.

Variables Contributing to Group Separation

To determine the relative extent to which each of the nineteen variables is contributing to group separation in each of the functions, the scale factor must be removed. For instance, the conventionalized weight for a variable with large variance must be adjusted upward in comparing it with other weights since the deviation scores by which it is multiplied will affect the discriminant score more than a variable with the same weight but with smaller variance. The adjustment is made by multiplying the elements of each vector by the square root of the corresponding diagonal elements of the W matrix; i.e., the sum of squared deviations from the group means. These adjusted weights are listed in Table V. The large negative weights are as important as the large positive weights.

Although the adjusted weights serve as an index for deciding which variables are useful in the over-all separation, answers are not readily apparent to such questions as, "Why are the social scientists so widely separated from the physical scientists?" Rather than attach *a priori* "meaning" to the various functions, a more operational approach is to actually go through the centroid computations and see what is happening. To illustrate the procedure, the following most widely separated groups were used: groups one and five on axis I.

In the tables which follow a $(+x)$ indicates the group mean was above the grand mean and a $(-x)$, below the grand mean. In column

TABLE V

RELATIVE CONTRIBUTION OF THE NINETEEN VARIABLES IN THE THREE FUNCTIONS

Variables	Function I: v_1W_{jj} Variable	Adjusted Weight
1. Sex	14	13.82
2. Scholastic average	13	11.88
3. Religion	9	7.75
4. IQ	1	7.46
Differential Aptitude Test	7	5.37
5. Numerical ability	3	2.75
6. Abstract reasoning	5	.75
Primary Mental Abilities	15	− .05
7. Verbal meaning	11	− .58
8. Reasoning	16	− 3.63
9. Number	17	− 3.80
10. Word fluency	19	− 5.23
Brandwein Inventory	18	− 7.06
11. Attendance	8	− 8.26
12. Interest	10	− 8.51
13. Width of interest	12	− 9.61
14. Perseverance	4	−10.60
15. Free periods	6	−11.61
16. Reading habits	2	−11.63
17. Personal history		
18. Ambition or drive		
19. Questing		

Function II: v_2w_{jj} Variable	Ad. Weight	Function III: v_3w_{jj} Variable	Ad. Weight
1	7.46	4	9.36
11	6.19	1	7.46
16	5.65	12	7.11
10	4.81	18	6.44
17	4.22	11	5.03
2	3.69	6	4.65
9	2.69	9	3.59
13	2.59	15	3.27
14	2.44	17	2.53
5	.45	8	1.53
8	.41	3	1.42
6	−1.20	14	.55
4	−1.68	7	− .70
3	−1.99	5	− 2.17
19	−3.62	16	− 5.45
12	−5.02	2	− 6.07
18	−5.40	10	− 8.14
15	−5.93	19	−10.27
7	−6.60	13	−10.80

v is the corresponding element of the conventionalized latent vector. Column xv contains the contribution of that variable to the discriminant score. The score itself is at the top of each table. Those variables contributing directly to a group's centroid displacement are listed in order, followed by those which modified the shift away from the center of the discriminant space.

TABLE VI
GROUP 1 ON AXIS I
($d_{11} = -2.680$)

Variate	x	v	xv
2	30.8	−.023	−.696
4	3.72	−.173	−.644
6	2.04	−.298	−.608
10	2.16	−.229	−.495
12	0.84	−.464	−.390
14	0.70	.679	.475
13	0.83	.545	.452
7	1.73	.131	.227
9	1.12	.188	.221

Group one (physical science) is high negative on I because, although above the mean on almost all variates, the (−) weighted variates out-weighed the (+). The variates contributing to the (−) shift were: school average, IQ, abstract reasoning, word fluency, interest. Those producing (+) modification were: perseverance, width of interest, verbal meaning, and number. One does not conclude from this that variables 14, 13, 7, and 9 are not important in displacing group 1 from the center of discriminant I.

TABLE VII
GROUP 5 ON AXIS I
($d_{15} = 1.882$)

Variate	x	v	xv
6	− 1.50	−.298	.447
4	− 2.46	−.173	.426
2	−14.9	−.023	.337
1	0.262	1.000	.262
12	− 0.46	−.464	.213
8	− 1.00	−.203	.203

Group 5 (social science) is high (+) on I because the variates with high (−) weightings were below the mean, and the high (+) weighted variates were either above the mean or very close to the mean. Important in the (+) shift were: abstract reasoning, IQ, SA, interest, and reasoning (all below the mean). Also contributing was the fact that there were more women than men in the group.

Further examination of the reasons for group separation shows that it is impossible to arrive at a single psychological interpretation of each function, as is done in certain types of factor analyses. The job of the discriminant function is to separate the groups, not identify

underlying dimensions. What is possible is to determine the variables which contributed most to the group separations and then make statements about the important differences between the groups.

Summary of the Results and Conclusions

The most important single result of the analysis of Brandwein's data is that an over-all variance-ratio test of the significance of the group separations (using Wilks' Lambda criterion) tended to reject the hypothesis that the nine groups are random samples from a common population. Such an over-all test of significance enables one to talk about group differences on individual variables with more confidence. The test also shows that even among a group of high IQ students, career development cannot be considered to be a random process.

Statistical significance does not imply practical significance, however. A study of centroids and centours indicated that a few of the group differences were sufficiently large to provide useful information for the career guidance of similar students at this school. But any practice of selecting students for, or barring them from, the special science program on the basis of these results would not be reasonable, since all of the three non-science groups greatly overlapped at least one of the six science groups.

The overlap between the science and non-science groups offers no support to the hypothesis put forward and the assumption implicit in several current practices that an entity exists called "science ability" which one either has or does not have. Although the results reported here cannot reject such a hypothesis, since it is possible that none of the nineteen variates used measure such "science ability" either alone or in combination, they do lend support to the view that aptitude for science is a function of general intelligence and previous scholastic achievement.

Attempts to give a *single* "meaning" to the functions proved futile. An investigation of the reasons for group separation showed that a variety of factors were affecting each discriminant score. A breakdown of the contribution of each variable to the discriminant score for the most widely separated groups gave insight into the relative importance of the main differences between these groups. IQ, scholastic average, interest (time spent in science hobby work), abstract reasoning, and sex were among the more frequently found discriminators. In all cases, it was a *combination* of factors which produced the observed group differences on each function.

The results of this empirical study are perhaps important for the following reasons. They lend encouragement to the further study of vocational-group differences among high ability students in order to

establish stable relationships which can then be used for guidance purposes. The utility of the multiple-group discriminant function for this area of research is demonstrated and procedures for learning from the results of discriminant analysis are suggested and illustrated. Although the resulting discriminant equations have limited application because of the nature of the sample, the fact tht the students remaining in some science field could not be "picked out" from the non-scientists should have implications for other schools designing special science programs. Self-identification with free-flow in and out of the program seems to be the most reasonable approach at this time with individual guidance playing an important role where reliable information is available.

In an effort to establish discriminant equations for more representative groups and examine their possible utility in the schools, the author is currently undertaking a five year study of over 700 boys in eastern Massachusetts. The hope is to see how precisely we can define the Potential Scientist Pool at the various stages of development (the boys range in age from 10 to 22). Also, movement into and out of the Potential Scientist Pool is being examined. This project is being sponsored by the U. S. Office of Education.

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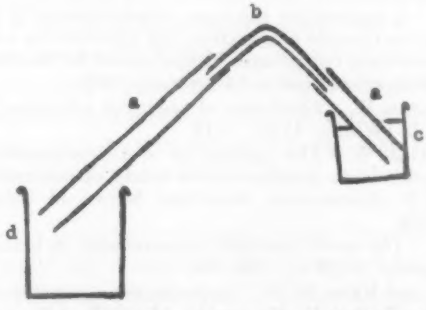
THE SIPHON . . . A VARIATION

Miss Rebecca Andrews, physics teacher at Woodrow Wilson High School, Washington, D. C., suggests a variation in the construction of a siphon.

The usual set-up of the demonstration of the simple siphon sometimes presents difficulties. Either a bent glass tube or a rubber tube is awkward to manage; a rubber tube is too loose and a bent glass tube is so rigid that in being handled it is apt to break. A combination of rubber tubing and bent glass has been found practicable.

Description of apparatus. Usually around a laboratory there are two short pieces of rubber tubing and a short glass tube that can easily be bent at right angles. The ends of the bent glass tube are inserted into the two pieces of rubber tubing, as shown in the diagram. A precaution that should be taken is to make the upper beaker smaller than the lower one so that, as the water drains, it will not spill onto the table. Between periods the water that has drained into the lower beaker can be quickly poured back into the upper one and the demonstration is then ready for a rerun with another class.

Other advantages of this set-up. Another advantage of a siphon set up this way is that pupils can see the water as it passes through the glass tube. An advantage to a tube of this type also is that this combination of the flexible rubber tubing and the rigid glass tubing allows its use for the demonstration on the diffusion of gases to conduct gas from the gas supply into a beaker wherein there is a porous cup.



Siphon: a. Rubber tube; b. Glass tube; c. Small beaker; d. Large beaker.

DUODENAL ULCERS KICK UP WHEN WEATHER CHANGES

Ulcers, like corns, kick up when the weather changes.

"Strong evidence" that bleeding from duodenal ulcers may be brought on by marked changes in temperature, resulting in stresses on the body as it is forced to adjust, was reported to the American Meteorological Society.

Hence, it is suggested that a warm climate with relatively little daily and seasonal variation in temperature would be the most suitable climate for those prone to suffer from duodenal ulcers.

The Effectiveness of a Television Series in Improving Kindergarten to Grade 2 Science Teaching Programs

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How effective can a science-oriented television series be in improving the science teaching program from Kindergarten classes up to the second grade? This article reports the results of an evaluation made in the New York City public schools of eight lessons telecast to these grades, from September to November, 1957. The telecast series had as its aim the exploration of the "whys" and "hows" of the world around the younger child by the use of simple experiments, stories, guessing games, pictures, film clips, and other visual techniques. A guide given to the participating teachers included pre-program questions, a brief description of what the telecast would show, and list of understandings which were expected as an outcome of viewing the program.

The materials in the Teachers' Guide for the eight Grade K-2 Science Corner telecasts are described on page 210 of the 1957–1958 WNYE Radio-Television Manual of the Board of Education of the City of New York as follows:

The Science Corner is concerned with the everyday science surrounding a child. By using familiar materials and happenings, simple experiments and games, the series hopes to capture and nourish the curiosity of a young student, and to stimulate him to explore the wonders he sees around him.

Through the thrill of his own discovery a child comes to understand and seek after the rewards of science. It is the purpose then of these programs to help every viewer become more aware of the science in his life so that he may continue to search, react and to interpret his world more thoughtfully.

Week of September 30—SOUNDS AROUND US—HOW DOES SOUND TELL US WHAT'S HAPPENING?

Before the telecast you may want to ask:

What sounds do you hear in bed at night?
What is a sound you like to hear in the kitchen?

On the telecast you will see:

How some sounds are made by tapping objects, blowing across bottles and other ways.

Simple sound makers we can all use. Games we can play with sound.

Understanding:

We can usually tell by the sound what's happening without looking.
Sounds are made in different ways.

Week of October 7—MAGNETS—WHAT DOES A MAGNET DO?

Before the telecast you may want to ask:

Are there any magnets in your house?
How did these magnets help?

On the telecast you will see:

How magnets separate things.
How to make a magnet.
How you can play "Mr. Detector."
Ways in which magnets help us.

Understanding:

Magnets attract things made of iron.
Magnets attract through paper and glass.

Week of October 14—WHEELS—WHY DO WE NEED WHEELS TO WORK FOR US?

Before the telecast you may want to ask:

What was the biggest wheel you ever saw?
What was the smallest wheel you ever saw?

On the telecast you will see:

How wheels help toys work.
How wheels do many other jobs for us.
Where wheels roll best.
A game to find the hidden wheels.

Understanding:

Wheels make moving easier by using rolling instead of dragging.

Week of October 21—FALL IS HERE—WHAT HAPPENS TO LIVING THINGS IN THE FALL?

Before the telecast you may want to ask:

How was the park changed since the summer?
How do some birds prepare for winter?

On the telecast you will see:

Why some birds fly south in the winter.
What the squirrel does to keep warm.

How people plan for the cold weather.
Things you can do to help some animals and birds.

Understanding:

Living things prepare for winter in different ways, by going to a warmer place, by building a home, by gathering a large supply of food and by going to sleep.

Week of October 28—SHADOWS, NIGHT AND DAY—HOW ARE SHADOWS MADE?

Before the telecast you may want to ask:

When do you see your own shadow best?
Tell about the time you saw a silly shadow?

On the telecast you will see:

How shadows can change during the day.
Where to look for nighttime shadows.
How to make long and short shadows.

Understanding:

A shadow is made when an object comes between the light and the ground. The length of the shadow depends on where the light is.

Week of November 4—WHAT SHALL WE WEAR?—WHY DO WE NEED SPECIAL CLOTHING?

Before the telecast you may want to ask:

What kind of clothing are you wearing today?
What special things do you use in the rain?

On the telecast you will see:

How some clothes keep us warm or cool.
How to tell what's good to wear in the rain.
Ways to find out what to use in the rain.
A "trick" to play on your friends.

Understanding:

Different kinds of clothing keep us cool, warm and dry. "Warm" clothing prevents the body heat from escaping too fast.

Week of November 18—MUSIC MAKERS—HOW DO WE MAKE MUSICAL SOUNDS?

Before the telecast you may want to ask:

If you could be any musical instrument, which would you like to be?

How do you make sounds come out of musical instruments?

On the telecast you will see:

What musical instruments do as we play them.
How to make different musical sounds.
Music you can make in school.
Why we have high and low notes.

Understanding:

Objects shake when they are making sounds. Big "sings" low and small "sings" high. Different musical instruments make different musical sounds

Week of November 25—THE WIND—HOW CAN THE WIND HELP US?

Before the telecast you may want to ask:

When did the wind play a trick on you?
How can you tell if it's windy outside right now?

On the telecast you will see:

What the wind is.
How the wind works for us.
How to tell where the wind comes from.
Ways to tell if the wind is strong.
How we can make breezes of our own.

Understanding:

The wind is moving. We put the wind to work for us. We can tell where the wind comes from by watching clouds, smoke and flags.

Plan of the Study

After each telecast, the teachers were asked to complete an 11 item questionnaire. A rating scale technique was used to measure the effectiveness of each program. Teachers were asked to indicate, by means of a four step rating scale (excellent, good, fair, or poor), the degree to which each of the following outcomes or criteria were achieved: 1) interest of children during the program; 2) the pace of the program; 3) appropriateness of subject matter for grade; 4) appropriateness of vocabulary for grade; 5) effectiveness of experiments in illustrating principle involved; 6) program's achievement of understandings stated in the WNYE Manual; 7) usefulness of telecast in general teching program; 8) rapport of telecaster with pupils; 9) effectiveness of pre-program questions in the WNYE Manual in

stimulating discussion; 10) pupil interest shown after program; 11) suggestion of additional activities by the program.

The weekly assessment was designed to sample the reactions of the viewers to each program so that revisions could be made as the series developed. Consumer reaction was sought, and the results were used in guiding the program producer to make adjustments on fairly short notice where responses warranted the advisability of doing so. A total of 388 Grade K-2 teachers in 41 different schools returned a total of 388 questionnaires after having rated individual programs at one time or another.

Findings of the Study

The teachers' opinion of the individual programs was very favorable. Table 1 lists the average percentage of teachers who reported good or excellent ratings for the 8 programs viewed by Grade K-2 classes. It will be noted that 94% of the teachers gave good or excellent ratings to the criterion "appropriateness of subject matter for your grade," 92% to "appropriateness of vocabulary for your grade," 86.1% to "usefulness of telecast in your teaching program in general," and 84.0% to "rapport of telecaster with the children."

Table 1

Number and Per Cent of the Combined Good and Excellent Ratings of the Reports of the Individual Weekly Programs of *The Science Corner* Series for Grades K-2

Criteria of Effectiveness (Individual Telecasts)	Combined Good and Excellent Ratings	
	Grades K-2	
	Number	Per Cent
1. Level of pupil interest during telecast	276	71.2
2. The pace of the program	244	62.9
3. Appropriateness of subject matter for your grade	365	94.0
4. Appropriateness of vocabulary for your grade	357	92.0
5. Effectiveness of experiments in illustrating the principle involved	304	78.4
6. Program's achievement of understandings stated in the WNYE Manual	308	79.3
7. Usefulness of telecast in your teaching program in general	334	86.1
8. Rapport of telecaster with the children	326	84.0
9. Effectiveness of pre-program questions in the WNYE Manual in stimulating discussion	301	77.6
10. Pupil interest shown after program	279	71.9
11. Suggestion of additional activities by the program	125	32.2
Total Number of Teachers	388	100.0

The findings for each criterion of the programs are discussed in the numbered sections which follow. The numbers correspond to the criteria of Table 1.

1. *Level of Pupil Interest During Telecast*

A total of 71.2% of the teachers rated the individual programs as good or excellent in maintaining an acceptable level of pupil interest during the telecasts. This may be considered a moderately good showing. Since the children in Grades K-2 are comparatively immature, they have a short interest span. A half hour science program is likely to tax the interest level of the younger and less bright children of this group.

The program which evoked the greatest degree of pupil interest during the telecast was *The Wind*, rated by 85.1% of the teachers as good or excellent (Table 2). This was probably due to the exciting film clips shown during the telecast and the dynamic nature of the demonstrations. The program rated second in order of interest was *Wheels*—75.9%; third was *Sounds Around Us* at 71.3%, and fourth was *Magnets* rated at 70.2%.

2. *The Pace of the Program*

The pace of the program was rated as good or excellent by 62.9% of the cooperating teachers (Table 1). It is not surprising that there was such difference of opinion. These judgments very likely were reflections of the teaching tempo and speaking rates of the respondents. Also, a topic unfamiliar to a viewer generally seems to be discussed too quickly; conversely a familiar topic seems to be presented too slowly.

There was a great divergence in the teachers' opinion regarding the pace of various programs. For example, *What Shall We Wear* was rated good or excellent by 76.5% of the respondents. *Magnets* was appraised by 65.0% and *Fall Is Here* by 42.5% of the teachers as being good or excellent. It is interesting to note that as the series unfolded there was a gradual but steady improvement in the ratings given to the pace of the program. Thus, the main purpose of the weekly appraisal reports seemed to be fulfilled in that the audience reactions guided the telecast directors in shaping the programs' pace and other characteristics.

3. *Appropriateness of Subject Matter for Grades K-2*

The evaluating teachers were extremely favorable in their opinion of the appropriateness of the subject matter of the telecasts, 94.0% rating it good or excellent in this regard (Table 1). The 94.0% reflects the viewing teachers' high approval of the judgment of *The Science*

Corner's writers in selecting the subject matter to be televised from the new Science Course of Study.

The appropriateness of the subject matter of all the programs was rated as good or excellent by over 90% of the respondents. Table 2 shows that *Sounds Around Us* received the highest rating, 98.6%; *The Wind* and *Wheels* followed with 96.3 and 94.8%, respectively. There was little doubt about the teachers' highly favorable opinion of the appropriateness of the subject matter of the programs.

4. *Appropriateness of Vocabulary Used for Grades K-2*

TABLE 2

PERCENTAGE OF GRADE K-2 TEACHERS WHO GAVE RATINGS OF GOOD OR EXCELLENT TO THE ELEVEN CRITERIA FOR APPRAISING INDIVIDUAL PROGRAMS

Criteria	Programs							
	Sounds Around Us	*Magnets*	*Wheels*	*Fall Is Here*	*Shadows*	*What Shall We Wear*	*Music Makers*	*The Wind*
1. Pupil Interest During Telecast	71.3	70.2	75.9	72.8	65.5	64.7	66.6	85.1
2. Pace of Program	42.5	65.0	63.8	56.4	73.1	76.5	71.8	70.3
3. Appropriateness of Subject Matter	98.6	94.7	94.8	90.9	92.3	91.2	92.4	96.3
4. Appropriateness of Vocabulary	91.0	94.8	89.7	87.3	92.3	94.1	92.3	100.0
5. Effectiveness of Experiments in Illustrating Principles	78.8	87.8	82.7	67.3	65.4	82.3	77.0	92.7
6. Achievement of Understandings in WNYE Manual	80.3	87.7	79.3	67.3	78.9	85.3	69.3	92.6
7. Usefulness in Teaching Program in General	90.9	91.2	86.2	71.0	84.6	91.2	82.1	96.4
8. Rapport of Telecaster with the Children	82.0	85.9	86.1	76.4	82.7	91.2	82.1	92.6
9. Effectiveness of Pre-Program Questions in WNYE Manual	77.3	68.4	75.9	72.8	82.7	88.3	74.4	92.6
10. Pupil Interest After Program	80.3	82.5	72.5	63.7	67.3	64.7	61.6	77.8
11. Suggestions of Additional Activities	36.4	35.1	39.6	16.4	28.8	26.5	33.3	44.4

An average of 92.0% of the cooperating Grade K-2 teachers rated the appropriateness of the vocabulary employed in *The Science Corner* programs as good or excellent (Table 1). This is quite an achievement in a subject like science in which many technical terms and abstract ideas require interpretation and explanation. It should be remembered that the ratings of vocabulary appropriateness were not based on tests given to the pupils but on teachers' judgments of what the pupils understood. Although the evidence is indirect, it nevertheless appears to be convincing. Teachers seem better able to judge pupils'

ability to master certain oral comprehension tasks by observing their classroom activities than by means of written tests. Also, the high percentage of agreement between so many observers, under such varying school conditions, lends objectivity and plausibility to the findings.

Table 2 presents the percentage of respondents reporting good or excellent ratings for each program. These ratings were given to *The Wind* by 100%, to *Magnets* and *What Shall We Wear* by about 94%, and to *Shadows* and *Music Makers* by about 92% of the cooperating teachers. The differences in the ratings were probably due to chance factors rather than to differences in subject matter or vocabulary difficulty.

5. *Effectiveness of Experiments in Illustrating the Principle Involved*

About 78% of the respondents thought the experiments were good or excellent for illustrating the principle involved. The teachers' estimates of the effectiveness of the experiments fluctuated with each telecast. For example, 87.8% of the respondents rated the telecast on *Magnets* as good or excellent, whereas 65.4% reported this rating for *Shadows* and 92.7% for *The Wind* (Table 2).

How well an experiment illustrates a principle depends upon the available apparatus and the complexity of the principle involved. If the apparatus is simple, reacts directly, and is easily observable there is more likelihood that it will be effective in illustrating a principle. On the other hand if a principle is complex and its operation is undramatic in its impact on an observer, it is more difficult to arrange an effective demonstration of said principle. An illustration in point is the program on *Magnets* which was rated high. It is simple in principle, lends itself to dramatic presentation, can be shown with simple apparatus, and its effects are easily and quickly observed. On the other hand, *Shadows—Night and Day* was considered less effective in illustrating its principle; it was characterized by a multiple-step development, a less dramatic impression on its observers, and a more involved passage from the physical observation to the abstract generalization.

6. *Programs' Achievement of Understandings Stated in the WNYE Manual*

The telecasts were considered by the teachers to be quite effective in achieving the understandings stated in the "Teachers' Guides" of the Station WNYE Manual. The understandings or outcomes that the pupils were expected to achieve as a result of viewing each program were listed in the WNYE Manual "Teachers' Guides." Over 79% of the Grade K-2 teachers judged the outcomes to have been achieved to a good or excellent degree. These judgments were made on

the basis of informal evaluations inasmuch as the children were too young to be examined by means of ordinary written tests.

Of the 8 individual telecasts, *The Wind* was rated highest, 92.6% of the respondents appraising it as good or excellent. *Fall Is Here* received the lowest rating, 67.3%.

Achievement of understandings in very young children is largely dependent upon their interests and experiences. The understandings expected in *The Wind* seemed closer to the interests and experiences of the Grade K-2 children than those of *Fall Is Here*. For example, in *The Wind* telecast, the understandings were—"The wind is moving. We put the wind to work for us. We can tell where the wind comes from by watching clouds, smoke and flags." These seem more closely tied to the experiences and interests of young New York City children than the understandings of *Fall Is Here*—"Living things prepare for winter in different ways, by going to a warmer place, by building a home, by gathering a large supply of food and by going to sleep."

7. *Usefulness of Telecasts in Your Teaching Program in General*

The respondents considered the telecasts to be very useful in their teaching programs in general. A total of 86.1% of these teachers rated the usefulness as good or excellent. For example, it was possible to relate language arts activities, discussions of outside environment, and clasroom routines to the programs viewed by the children. In this respect *The Science Corner*, like other audio-visual aids, supplied several avenues of enrichment and correlation with real life experiences.

The highest rated program was *The Wind*, chosen by 96.4% of the respondents as good or excellent. This was followed by *Magnets* and *What Shall We Wear* both of which received equal ratings from 91.2% of the cooperating teachers (Table 2). *The Wind* suggests many useful activities such as stories, dances, songs, discussions of weather and climate, of clothes, and a host of other avenues for teaching. The varied usefulness of the other programs was noted with apparent satisfaction, though to a lesser degree, by the respondents.

8. *Rapport of Telecaster with the Children of Grades K-2*

In their responses, 84.0% of the teachers rated the rapport between the telecaster and the children as good or excellent. The telecaster had an attractive appearance, a friendly manner, a pleasant voice, and a warm personality which the television audience evidently liked. Each program closed with a few minutes of story telling by the telecaster which helped create a closer bond between her and the audience. Table 2 shows that *The Wind* and *What Shall We Wear*

received ratings of good or excellent from 92.6% and 91.2%, respectively, of the respondents. The ratings given the remaining programs ranged between 76% and 86%. In general, it may be stated that the rapport of the telecaster with the children was of a very high order.

9. *Effectiveness of Pre-program Questions in the WNYE Manual in Stimulating Discussion*

Pre-program questions were available for each program listed in the "Teachers' Guides" of the WNYE Manual. Each program provided questions under the heading, "Before the telecast you may want to ask." For example, in connection with *Shadows*, one of the questions was, "When do you see your own shadow best?"

Pre-program questions are very useful in preparing and motivating classes for audio-visual instruction of all types. Repeated experience with an audio visual aid enables the instructor to refine the pre-program questions. However, this was not possible because the present evaluation of *The Science Corner* was being conducted for the first time. Nevertheless, the pre-program questions proved to be quite valuable as was shown by the superior ratings expressed by over 77.6% of the teachers who made use of them (Table 1).

10. *Pupil Interest Shown After Program*

One criterion of the effectiveness of *The Science Corner* was the degree of pupil interest shown after the program had been completed. Almost 72 per cent of the teachers reported good or excellent results in respect to this criterion (Table 1). The figure of 71.9%, representing the level of interest after the program, was slightly higher than the level of pupil interest reported during the telecast. Pupil interest may have increased after the program because of additional opportunities pupils had at that time to discuss and to ask questions about the experiments they saw.

No attempt was made to measure the effect of time lag on the interest of the pupils. The reports of the teachers were based on their observations of the pupils less than a week after the telecast had been completed. Pupil interest varied with the subject of the telecasts as had been expected. For example, 82.5% of the respondents listed the interest as good or excellent for *What Does A Magnet Do* but only 61.6% reported this rating for *Music Makers* (Table 2). This difference may have been due to the fact that activities with *Magnets* presented more opportunities for children to try out experiments by themselves, whereas the *Music Makers* required apparatus and procedures that most children could not handle very readily.

11. *Suggestions of Additional Activities by the Program*

A total of 32.2% of the teachers thought the program was good or excellent in suggesting additional activities for classroom work in science (Table 1). The suggestion of additional activities presupposes some familiarity and knowledge of science content and also some creative imagination in this area on the part of the teachers. However, this group of teachers had little experience and would ordinarily have found it very difficult to utilize activities other than those shown directly on the television programs.

In Table 2 the percentage of good or excellent ratings is seen to vary from 16.4% for *Fall Is Here* to 44.4% for *The Wind.* The latter topic suggested numerous demonstrations. For example, winds or air in motion moved pin wheels, flags, smoke, paper, balloons, and sailboats. *Fall Is Here,* on the other hand, placed a greater emphasis on observation rather than demonstration. This made it more difficult for the large number of Grade K-2 teachers, who were inexperienced in science activities, to suggest usable demonstrations in addition to those they viewed on *The Science Corner* telecasts.

In general, considering the difficulty of making new suggestions in any situation, the inexperience of the Grade K-2 teachers involved, and the large number of blank responses received, the 32.2% of good or excellent ratings may be interpreted as a favorable outcome in regard to the criterion, "suggestions of additional activities."

Conclusions

A. Effectiveness of the Telecasts in Respect to the Pupils
   1. Pupils' interest in their environment was greatly stimulated. They were made more aware of science in their lives.
   2. The pupils' interest was reported to be high during as well as after the programs.
   3. The programs were highly effective in increasing the children's fund of science information. They successfully achieved the informational objectives stated in the WNYE Teachers' Guide.

B. Effectiveness of the Telecasts in Respect to the Teachers
   1. The demonstrations shown in the telecasts were considered to be very practicable for teachers and effective in illustrating principles of science to their pupils.
   2. The series was reported as being extremely valuable to the teachers in showing them activities useful in their teaching programs in general.
   3. The telecasts were useful in suggesting additional science activities to the teachers of Grade K-2 classes.

4. The teachers considered the series to be excellent as a useful classroom aid.
5. The pre-program questions of the Teachers' Guide in the WNYE Radio-Television Manual proved to be very effective in stimulating pupil discussion.

C. Effectiveness of *The Science Corner* as a Television Production
1. The pace of the program was very satisfactory.
2. The subject matter was considered to be very highly appropriate for the grade levels at which the programs were viewed.
3. The vocabulary was considered to be very highly appropriate for the pupils of the grades for which the programs were telecast.
4. The rapport between the telecaster and the children was estremely satisfactory.

EARTH FOUND PEAR-SHAPED INSTEAD OF EQUATOR-BULGING

The earth is pear-shaped, not bulging at the equator as has been thought.

Studies of the orbital flight of Vanguard I show that the earth's sea level is 50 feet higher than expected in the north polar regions and 50 feet lower than expected in the south polar regions. Accenting the pear shape is the fact that outside the polar areas sea levels in the Northern Hemisphere are 25 feet lower than thought, and 25 feet higher in the Southern Hemisphere.

MIXED ANIMAL ENZYMES PRODUCE LUMINESCENCE

For the first time, scientists have removed luciferin from a fish. Luciferin is a light-emitting compound found in some "glow-in-the-dark" creatures, such as fireflies and glowworms.

Working in Japan with luciferin from a South Seas fish known as kinme modoki, scientists were able to mix two compounds that produce luminescence and get a luminescent reaction, although the compounds came from different animals.

The luminescent extracts are the enzyme luciferase and a substance known as luciferin which, upon decomposing, emits light. Previous attempts to obtain light when mixing luciferase from one animal with luciferin of another type had failed.

However, scientists reported they were able to get a cross-reaction—luminescence—using extracts from two different types of fish. Even more remarkable is the fact that extracts from one of the fish, which is about the size of a large goldfish, reacted with those of a luminescent crustacean.

Luminescence interests biologists because it is a useful tool in investigations of fundamental problems that apply to all living things. For example, it can be used in studies of the "effects of drugs, heat and cold, and antibiotics on organisms as a whole or on their various life processes such as respiration, reproduction and digestion."

PROBLEM DEPARTMENT

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. **Solutions should be in typed form, double spaced.**
2. **Drawings in India ink should be on a separate page from the solution.**
3. **Give the solution to the problem which you propose if you have one and also the source and any known references to it.**
4. **In general when several solutions are correct, the one submitted in the best form will be used.**

LATE SOLUTIONS

2633. *W. R. Talbot, Jefferson City, Mo.*

2637. *Joseph Hooker, Egg Harbor, N. J.*

2637. *Lois Kragengring, Interlaken, N. Y.*

2637. *Joanna M. Wilson, Covert, N. Y.*

2637. *Walter R. Warne, St. Petersburg, Fla.*

2641. *Darius Green, Mobile, Ala.*

2645. *J. Byers King, Denton, Md.*

2645. *Antonio Rossmas, Coral Gables, Fla.*

2648, 2649, 2652. *Phillip Fung, Pocatello, Idaho.*

2649. *Nathan Daboll, Junius, N. Y.*

2653. *Proposed by Alan Wayne, Baldwin, N. Y.*

Given two different positive numbers, find the necessary and sufficient condition that their arithmetic mean will be closer in value to their positive geometric mean than will either of the given numbers.

Solution by C. W. Trigg, Los Angeles City College

Since the numbers are different, take $a<b$. Then it is required that

$$\tfrac{1}{2}(a+b)-\sqrt{ab}<\sqrt{ab}-a$$

Hence

$$3a+b<4\sqrt{ab}.$$

$$9a^2+6ab+b^2<16ab$$
$$b^2-10ab9a^2<0$$
$$(b-a)(b-9a)<0$$

Therefore the necessary and sufficient condition sought is

$$a<b<9a.$$

A solution was also offered by Hermann Boeckmann, Bloomington, Ill.

2654. *Proposed by John Nayler, Calgary, Alberta, Canada.*

A man working on the surface of a space-ship refueling craft in the form of a perfect cube is, for safety, tied to an anchor ring by means of a rope equal in length to one edge of the cube. Find the percentage of the total surface area of the craft accessible to the man if the anchor is (a) at one corner, or alternately, (b) in the center of one face.

Solution by C. W. Trigg, Los Angeles City College

Neglecting the amount of rope necessary to tie the rope to the anchor ring and to the man, as well as the distance the man can reach beyond the end of the rope, then

(a) $$P_a=\frac{(3/4)\pi e^2\times 100}{6e^2}=100\pi/8\doteq 39.27\%.$$

(b) $$OA=e/2,$$

so angle

$$BOC=60°-45°=15° \text{ or } \pi/12.$$

Sector

$$DOC=\pi e^2/24.$$

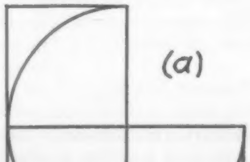
Triangle

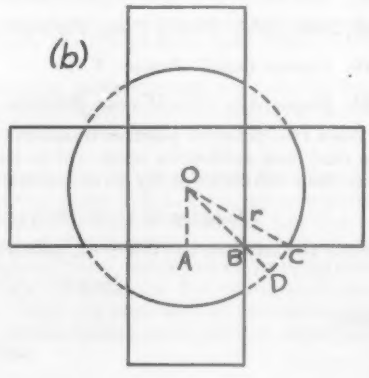
$$BOC=\tfrac{1}{2}\cdot\tfrac{1}{2}e\cdot e\tfrac{1}{2}(\sqrt{3}-1)=e^2(\sqrt{3}-1)/8$$

$$P_b=\frac{\{\pi e^2-8[\pi e^2/24-e^2(\sqrt{3}-1)/8]\}\times 100}{6e^2}$$

$$=\frac{(2\pi/3+\sqrt{3}-1)(100)}{6}\doteq 47.11\%.$$

A solution was also offered by Hermann Boeckmann, Bloomington, Ill.





2655. *Proposed by Brother Felix John, Philadelphia, Pa.*

Given five numbers a, b, c, d, and e; a, b, and c, are in Arithmetic Progression; b, c, and d are in Geometric Progression; c, d, and e are in Arithmetic Progression; $ac=2e$; $2d+e=bc$. Find the numbers.

Solution by Dale Woods, Pocatello, Idaho

From the information given we have the following equations:

(1) $$ac=2e$$

(2) $$2d+e=bc$$

(3) $$b-a=c-b \quad \text{or} \quad 2b=c+a$$

(4) $$d-c=e-d \quad \text{or} \quad 2d=e+c$$

(5) $$c/b=d/c \quad \text{or} \quad c^2=bd.$$

Solve (3) for a then multiply by c obtaining

$$ac=2bc-c^2.$$

By (1)

$$2bc-c^2=2e$$

From (2) and (5)

$$4d+2e-bd=2e$$

$$4d=bd$$

$$4=b.$$

Using (2) and (4) after substituting the value obtained for b

$$2d+e=4c$$

$$2d-e=c$$

$$2e=3c.$$

From (1)

$$ac=3c$$

$$a=3.$$

By (3)

b

$$c=2b-a$$

$$c=5$$

and

$$e=15/2.$$

By (5)

$$c^2=bd$$

$$25/4=d$$

Therefore

$$a=3, \quad b=4, \quad c=5, \quad d=25/4, \quad \text{and} \quad e=15/2.$$

Solutions were also offered by Hermann Boeckmann, Bloomington, Ill.; John Friedlein, St. Charles, Ill.; Margaret Joseph, Milwaukee, Wis.; J. Byers King, Denton, Md.; John Q. Taylor King, Austin, Texas; Frank Milne, Halifax, N.S., C. W. Trigg, Los Angeles, Calif.; Floyd D. Wilder, Bethany, Okla.; and the proposer.

2656. *Proposed by J. W. Lindsey, Amarillo, Texas.*

If the top of a ship's mast is 60 feet above the sea, how far must the ship sail before it disappears below the horizon? Take the radius of the earth as 4000 miles.

Solution by John Tripp, Lansing, Mich.

Given;

CB = radius of earth = 4,000 mi. = 21,120,000 ft.

DB = radius of earth = 4,000 mi. = 21,120,000 ft.

AD = mast of ship from sea = 60 ft.

CE = line of sight, or horizon line

Find;

arc CD

For the solution we will use radian measure.

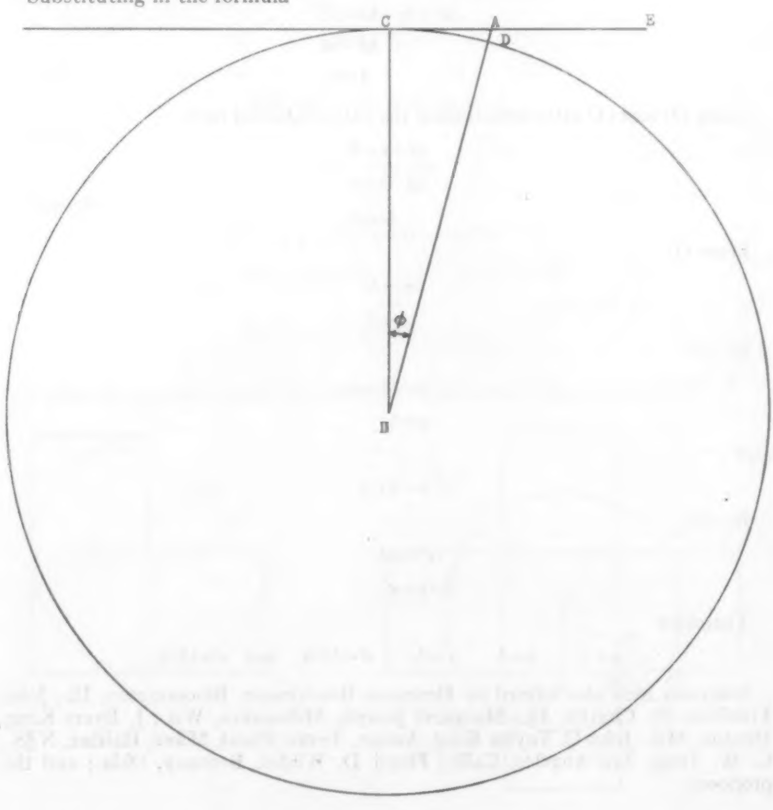
$$\cos\phi = \frac{CB}{BD+DA} = .99999716$$

$$\phi = 8 \text{ min. } 14 \text{ sec., or } 494 \text{ sec.}$$

Changing ϕ to radians we get

494 sec. = .0023712 rad. (1 sec. = .0000048 rad.)

Substituting in the formula



$$s=r\theta \qquad (\theta=\text{number of radians in } \phi)$$

we get

$$CD=4{,}000\times .0023712$$
$$CD=9.4848 \text{ mi.}$$

Thus we may say that the ship will sail 9.4848 mi. before the ship will go below the horizon.

Solutions were also offered by Hermann Boeckmann, Bloomington, Ill.; C. W. Trigg, Los Angeles, Calif; and the proposer.

2657. *Proposed by Doris E. Helms, Hellertown, Pa.*

Devise, give an example of, and offer justification for a system of checking addition of numbers written to the base eight by casting out sevens.

Solution by the proposer

System of Checking, Illustrated

(All numbers in the example are written to the base 8. The base will not be written each time.)

Problem		*Check*
173 ——	13 ——	4
+357 ——	17 ——	1
		5
552 ——	14	5

The system is: Take each term to be added, one at a time. In each one add the digits, as above, for example, in the 173, add the 1, the 7, and the 3, giving to the base 8 the number 13. Then divide this sum of the digits by 7, giving the residual of 4. Having done this to each term to be added, add the individual residuals, as above, the 4 and the 1, giving the number 5 as the check number. Then go to the answer and do the same thing. If you get the same residual as the sum of the individual residuals, the computation is probably correct.

Justification for System

(A) With numbers written to the base 8, the residual that is obtained by dividing a number by 7 is the same as the one obtained by dividing the sum of the digits of the number by 7. (As in the example, 173 divided by 7 gives the same remainder as the sum of the digits 1, 7, and 3 divided by 7.)

Proof of (A)

To the base 8, any number may be expressed as:

$$N=a_0+8a_1+64a_2+512a_3\cdots \text{etc.}$$

Using congruences,

$$N\equiv a_0+a_1+a_2+a_3\cdots \text{etc. (mod. 7)}$$

Therefore,

$$\frac{N-(a_0+a_1+a_2+a_3\cdots \text{etc.})}{7}=I \text{ (an integer)}$$

or

$$\frac{N}{7}-\frac{(a_0+a_1+a_2+a_3\cdots \text{etc.})}{7}=I$$

Then, since N is the number and since $(a_0+a_1+a_2+a_3\cdots$ etc.) is the sum of the digits, it has been proved that a number written to the base 8 when divided by 7 gives the same residual as the sum of the digits divided by 7. For the only way we can get the *integer*, not fraction, which is required in the above proof is if the residual of the $N/7$ is the same as the residual of

$$\frac{(a_0+a_1+a_2+a_3\cdots \text{etc.})}{7}.$$

(B) The sum of the residuals is equal to the residual of the sum. (As in the example, $4+1=5$.)

PROOF OF (B)

Let the first number be N_1, the second number N_2. Then the sum of the numbers will be N_1+N_2.

Then,

$$\frac{N_1}{7}=Q_1+\frac{r_1}{7}, \quad \text{or} \quad N_1=7Q_1+r_1$$

$$\frac{N_2}{7}=Q_1+\frac{r_2}{7}, \quad \text{or} \quad N_2=7Q_2+r$$

Therefore,

$$N_1+N_2=7(Q_1+Q_2)+(r_1+r_2)$$

And,

$$\frac{N_1+N_2}{7}=(Q_1+Q_2)+\frac{(r_1+r_2)}{7}$$

$$\frac{N_1+N_2}{7}$$

is the sum divided by 7.

$$(Q_1+Q_2)+\frac{(r_1+r_2)}{7}$$

is the sum of the individual numbers each divided by 7 first. Since the two are equal, the residual on each side of the equality must be the same. Thus it is proved that the sum of the residuals is equal to the residual of the sum.

2658. *Proposed by P. C. Tomljanovic, Tucson, Ariz.*

At what point on the known diameter of a coin should the center of a coin (of equal area) be placed such that the covered area is equal to the exposed area?

Solution by the proposer

1) Equation of C_1:

$$x^2+y^2=r^2$$

2) Equation of C_2:

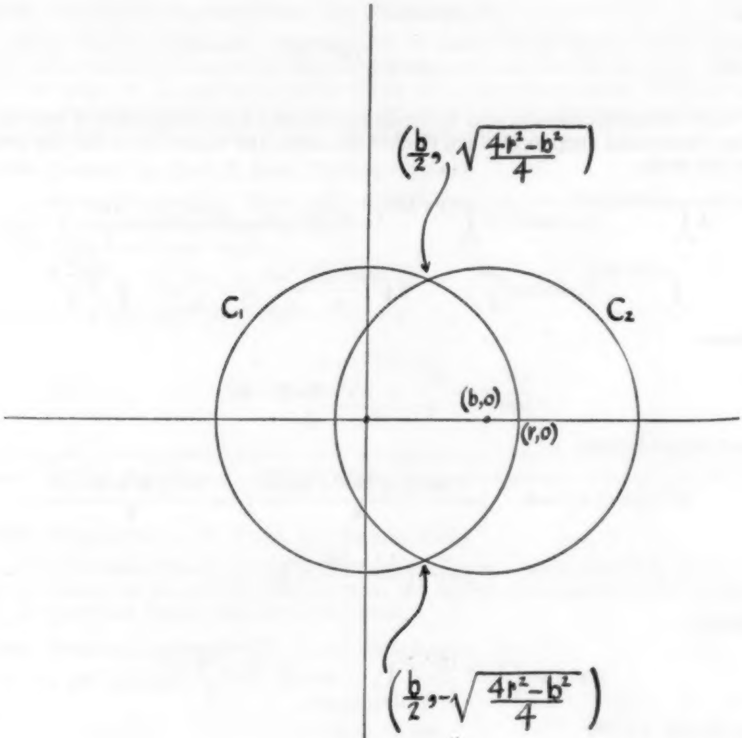
$$(x-b)^2+y^2=r^2$$

To determine points of intersection:
From 1)

$$y^2=r^2-x^2$$

and from 2)

$$y^2=r^2-(x-b)^2;$$



then

3) $$r^2-x^2=r^2-(x-b)^2$$

or

4) $$x^2-2bx+b^2=x^2$$

or

5) $$x=\frac{b}{2}\ ;$$

substituting 5) in 1) we obtain

6) $$\frac{b^2}{4}+y^2=r^2$$

or

7) $$y^2=r^2-\frac{b^2}{4}$$

or

$$8)\qquad y=\pm\sqrt{\frac{4r^2-b^2}{4}}$$

Now compute common area by integration from x axis to top point of intersection (horizontal stripping); then double this area, and equate it to half the area of the circle.

$$2\int_0^{\sqrt{(4r^2-b^2)/4}}(x_1-x_2)dy=2\int_0^{\sqrt{(4r^2-b)^2/4}}\left[\sqrt{r^2-y^2}-(b+\sqrt{r^2-y^2})\right]dy=\frac{\pi r^2}{2}$$

$$\int_0^{\sqrt{(4r^2-b^2)/4}}(-b)dy=\frac{\pi r^2}{4};\qquad -b\sqrt{\frac{4r^2-b^2}{4}}=\frac{\pi r^2}{4};\qquad \frac{\pi r^2}{4b}=-\sqrt{\frac{4r^2-b^2}{4}};$$

hence

$$\frac{\pi^2r^4}{16b^2}=r^2-\frac{b^2}{4};\qquad \pi^2r^4=16r^2b^2-4b^4;$$

now let $z=b^2$; then

$$4z^2-16r^2z+\pi^2r^4=0;\qquad z=\frac{16r^2\pm\sqrt{256r^4-16\pi^2r^4}}{8};\quad z=\frac{16r^2\pm4r^2\sqrt{16-\pi^2}}{8};$$

$$z=(r^2)\left(\frac{4\pm\sqrt{16-\pi^2}}{2}\right);$$

hence

$$b^2=(r^2)\left(\frac{4\pm\sqrt{16-\pi^2}}{2}\right);\qquad b=r\sqrt{\frac{4\pm\sqrt{16-\pi^2}}{2}}$$

or finally $b=.88r$

Solutions were also offered by William Johnson, Cleveland, Ohio; and C. W. Trigg, Los Angeles, Calif.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2648, 2649. *Lee H. Mitchell, New Trier High School, Winnetka, Ill.*

2655. *James E. Ward, University of Maryland, College Park, Md.*

PROBLEMS FOR SOLUTION

2677. *Proposed by C. N. Mills, Sioux Falls College, S. D.*

From a book on Chinese mathematics. Given a quadrant of a circle of radius R. Three equal circles, radius d, are inscribed so that one of them is tangent to the quadrant arc at its midpoint, and is tangent to the other two circles which are tangent to the quadrant radii. Show that the radius of each circle is $R(\sqrt{3}-\sqrt{2})$.

2678. *Proposed by Brother Fidelis Leo, Pittsburgh, Pa.*

Given a circle of diameter 10 units with its center at the origin. At the point (0, −2) a circle is drawn with diameter 6 units and inscribed in the large circle. At the point (0, 3) another circle is drawn with diameter 4 units. What is the diameter of the largest circle that can be drawn in the first quadrant between the three circles. (Give a solution other than by measuring.)

2679. *Proposed by Cecil B. Read, Wichita, Kansas.*

In solving the problem: What point on the hyperbola $x^2-y^2=a^2$ is nearest the origin? a student proceeds as outlined.

Let L distance from origin

$$L=\sqrt{x^2+y^2}$$

substituting the value of y^2 from $x^2-y^2=a^2$

$$L=\sqrt{2x^2-a^2}$$

$$\frac{dL}{dx}=\frac{x}{\sqrt{2x^2-a^2}}.$$

Letting $dL/dx=0$, $x=0$, but for $x=0$, y is imaginary. But the student can obviously see that the points $(\pm a, 0)$ are nearer the origin than any other point. What is wrong?

2680. *Proposed by C. W. Trigg, Los Angeles, Calif.*

A right circular cone is cut in an elliptical section by a plane perpendicular to a given element of the cone at B. Show that the center of curvature of the vertex, B, of the ellipse lies on the axis of the cone.

2681. *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the system:

$$y^2+yz+z^2=43$$
$$z^2+zx+x^2=109$$
$$x^2+xy+y^2=31.$$

2682. *Taken from "Mathematical Pie," Doncaster, England.*

A shopkeeper ordered 19 large and 3 small packets of marbles, all of the same sort. When these arrived at his shop, the box had been handled so roughly that all the packets had come open and the marbles were loose in the box. He counted 224 marbles, so how many should he put into a large packet and into a small packet respectively?

Books and Teaching Aids Received

PLANE GEOMETRY, by Avery, revised by William C. Stone, *Union College, Schenectady, N. Y.* Cloth. Pp. ix+498. 15×23 cm. 1958. Allyn and Bacon, Inc., Boston, Mass.

CHEMISTRY, MAN'S SERVANT, by Leonard J. Fliedner, *Stuyvesant High School, New York City,* and Louis Teichman, *George Washington High School, New York City.* Cloth. Pp. ix+625. 16×23.5 cm. 1958. Allyn and Bacon, Inc., Boston, Mass.

METHODS BASED ON THE WIENER-HOPF TECHNIQUE FOR THE SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS, by B. Noble, *The Royal College of Science and Technology, Glasgow.* Cloth. Pp. x+246. 14×21.5 cm. 1959. Pergamon Press, Inc., 122 E. 55th Street, New York 22, N. Y.

EDUCATION AND FREEDOM, by H. G. Rickover. Paper. Pp. 258. 13.5×20.5 cm. 1959. E. P. Dutton and Co., New York, N.Y.

SOLID GEOMETRY, by A. M. Welchons, W. R. Krickenberger, and Helen R. Pearson, *The Arsenal Technical High School, Indianapolis, Indiana.* Cloth. Pp. v+345. 15.5×23.5 cm. 1959. Ginn and Co., Statler Building, Boston 17, Mass., Price $3.48.

TRIGONOMETRY FOR TODAY, by Milton Brooks, A. Clyde Schock, in consultation with Albert I. Oliver, Jr., Cloth. Pp. vi+102. 14×21 cm. 1959. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N.Y. Price $4.20.

ELEANOR ROOSEVELT, by Alfred Steinberg. Cloth. 127 Pages. 13.5×20.5 cm. 1959. G. P. Putnam's Sons, 210 Madison Ave., New York, N. Y. Price $2.00.

THEODORE ROOSEVELT, by Henry Thomas. Cloth. 128 pages. 13.5×20.5 cm. 1959. G. P. Putnam's Sons, 210 Madison Ave., New York, N.Y. Price $2.00.

SPACE PRIMER, An Introduction to Astronautics. Paper. Pp. vii+72. 9×21.5 cm. 1959. Convair Division of General Dynamics Corp., P.O. Box 1128, San Diego, Calif. (Bulk quantities at a nominal cost)

RAYS—VISIBLE AND INVISIBLE, by Fred Reinfeld. Cloth. 204 pages. 13.5×20 cm. 1958. Sterling Publishing Co., Inc., 419 4th Avenue, New York 15, N. Y. Price $3.50.

ELEMENTARY ALGEBRA, by Donald S. Russell, *Ventura College, California.* Cloth. Pp. ix+297. 15×23 cm. 1959. Allyn and Bacon, Inc., 150 Tremont Street, Boston 11, Mass. Price $4.59.

PHYSICAL SCIENCE, A BASIC COURSE, by John C. Hogg, Judson B. Cross, and Kenneth E. Vordenberg. Cloth. Pp. ii+604. 17×24 cm. 1959. D. Van Nostrand and Co., Inc., 120 Alexander Street, Princeton, N. J. Price $4.96.

The Macmillan Science/Life Series, Books 1–6:

- Book 1, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, and Mary W. Moffit, Pp. 122, Price $2.32;
- Book 2, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, and Mary W. Moffit, Pp. 154, Price $2.48;
- Book 3, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, and George Reynolds, Pp. 250, Price $2.72;
- Book 4, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, Eleanor Delaney, and George Reynolds, Pp. ix+262+xxvi, Price $2.80;
- Book 5, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, and J. Myron Atkin, Pp. ix+310+xxvi, Price $2.88;
- Book 6, by J. Darrell Barnard, Celia Stendler, Benjamin Spock, Margaret Braidford, and J. Myron Atkin, Pp. ix+310+xxvi, Price $2.96.

All books in series: cloth. 19×23.5 cm. 1959. Macmillan Co., 60 5th Avenue, New York 11, N. Y.

MATHEMATICS TO USE, Revised Edition, by Mary A. Potter, *Consultant in Mathematics, Racine, Wisconsin.* Cloth. Pp. viii+503. 15.5×23 cm. 1959. Ginn and Co., Inc., Statler Bldg., Boston 17, Mass. $3.72.

ROCKET AMATEUR'S GUIDEBOOK. Paper. 23 pages. 21.5×28 cm. 1959. Space Products Corporation, 38 E. 57th Street, New York 22, N. Y. Price $.75.

ARITHEMETIC FOR CHILD DEVELOPMENT, by Lowry W. Harding. Paper. Pp. ix+427. 21×28 cm. 1959. William C. Brown Company, Dubuque, Iowa. Price $6.00.

INTRODUCTION TO SYMBOLIC LOGIC AND ITS APPLICATION, by Rudolf Carnap. Paper. Pp. xiv+241. 13×20.5 cm. 1959. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.85.

THE VALUE OF SCIENCE, by Henri Poincare'. Paper. Pp. iii+147. 13×20.5 cm. 1959. Dover Publications, Inc., 920 Broadway, New York 10, N.Y. Price $1.35.

ELEMENTARY-SCHOOL SCIENCE AND HOW TO TEACH IT, Revised Edition, by Glenn O. Blough, Julius Schwartz, and Albert J. Huggett. Cloth. Pp. xvi+608. 19×25.5 cm. 1958. A Holt-Dryden Book, Henry Holt and Co., New York, N. Y.

THE MAINSPRING OF HUMAN PROGRESS, by Henry Grady Weaver. Paper. 279 pages. 13×19 cm. 1958. The Foundation for Economic Education, Inc., Irvington-on-Hudson, N. Y.

RADIOACTIVITY MEASURING INSTRUMENTS, by M. C. Nokes. Cloth. Pp. viii+75. 14×21.5 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $4.75.

A GUIDE TO NUCLEAR ENERGY, by R. F. K. Belchem. Cloth. Pp. vii+'77. 12×18 cm. 1958. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $3.75.

THE WONDERWORLD OF SCIENCE, Revised Book 8, by Morris Meister, Ralph E Keirstead, and Lois M. Shoemaker. Cloth. 360 pages. 15×21 cm. 1959. Charles Scribner's Sons, 597 5th Avenue, New York 17, N. Y. Price $3.12.

OLIVER PETE IS A BIRD, by Carroll Lane Fenton and Dorothy Constance Pallas. Cloth. 47 pages. 18×20 cm. 1959. The John Day Co., Inc., 210 Madison Avenue, New York, N. Y. Price $2.75.

ADVENTURES IN SCIENCE, by Willard J. Jacobson, Robert N. King, and Louise E. Killie. Cloth. Pp. xi+387. 17×23 cm. 1959. American Book Co., 55 5th Avenue, New York 3, N. Y. Price $3.56.

Book Reviews

INTRODUCTION TO THE THEORY OF SETS, by Joseph Breuer, translated by Howard F. Fehr. Cloth. Pages viii+108. 14×21 cm. 1958. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $4.25.

In recent years the concept of "set" has become as prominent as that of "function" a generation ago. Without entering into any discussion of whether or not the concept will remedy any (or all) mathematical ills, it does seem that teachers and students need a somewhat elementary discussion. This book seems of unusual value in meeting this need.

The English of the translation reads smoothly. The illustrations leading into the subject involve material familiar to the teacher or student. The book is recommended for an introduction to set theory for teacher or student. It is not light reading, and will discourage many an "interested layman" mentioned in the preface. However, if studied carefully, the book will be very valuable in helping the reader gain a better knowledge of set theory. The book makes no pretense of being an exhaustive treatise, but it does provide a short bibliography for those who wish supplementary material. This reviewer recommends the book as a valuable addition to private or school library.

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BASIC PRINCIPLES OF CHEMISTRY, by Eugene C. Winslow. Cloth. Pages v 284. 15×23 cm. 1958. D. Van Nostrand Co., Inc., 120 Alexander Street, Princeton, N. J. Price $4.75.

This book is a first year college chemistry text which puts the main emphasis on principles and their everyday applications. The author states in the preface: "An attempt has been made to sift out much of the factual material which the student might have in preparatory courses. The author has tried to include those little sidelines in the discussion of each topic which have seemed to interest his many students over the past years. He strongly believes that there is a fascinating story in chemistry and this book attempts to tell part of the story."

Much emphasis is given to the periodic table. The author endeavors to tie the subject of properties to structure and succeeds very well in accomplishing this.

The material covered is similar to that found in most general college chemistry texts. The first four chapters deal with basic principles, the chemical equation, physical states and the atmosphere.

These are followed by two chapters treating the chemistry of oxygen and hydrogen. Chapters seven through ten inclusively deal with the periodic table and atomic structures. Chapters eleven through fourteen include the chemistry of water and solutions. The remaining seven chapters cover in a brief but clear manner the alkali metals, organic chemistry, biochemistry, electrochemistry and nuclear energy. There is also included in the Appendix a very good treatment of nomenclatures.

The paper, binding, and type found in the book are very good. The illustrations are rather limited, but well selected. A well-planned set of review questions is found at the end of each chapter.

The author is to be complimented on having produced a book of less than 300 pages. He has done an excellent job of selecting material. Too many of the general chemistry texts have become encyclopedic in nature. Here is a textbook that should be a help rather than a handicap to the student.

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